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Investigating the Use of M-Health for Learning and Clinical Training by Medical Students in Ghana

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Abstract

There is a challenge with healthcare access in most developing countries. With the high rate of mobile technology penetration in these countries, there is a strong belief that mobile technology can help address this and other health system and education challenges. This study investigated how clinical year medical students in Ghana used m-health and with what outcomes. This was a mixed-methods study to assess what technologies students used, what the impact of use was, what enablers and barriers they encountered, what factors explained m-health adoption and what the attitudes of students, staff and faculty members were towards m-health use. The study was conducted in four out of five medical schools in Ghana with clinical year students namely, Kwame Nkrumah University of Science and Technology School of Medical Sciences (KNUST-SMS), University of Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine and Health Sciences (UDS-SMHS) and University of Ghana School of Medicine and Dentistry (UG-SMD). Online and paper questionnaires were distributed to 828 students and 291 questionnaires were returned. Questionnaires from dental students at UG-SMD (n = 5) were excluded from the analysis. Two focus group discussions were held involving seven students while three students, seven faculty members and five staff were interviewed. Qualitative data were analysed using thematic analysis. Only one student did not own a mobile device. About 78% of students reported using m-health at some point during their medical education. The most popular devices used by students were laptop computers (90.8%), smartphones (66.2%), cellular phones (46.6%) and tablets (44.1%). Over 84% of the students owned Android devices, while 21% owned iPhones and iPads. Majority of students owned three devices or less. Students used mobile technologies in ways that suited their learning needs and contexts. M-health helped students to participate better in lessons and improve their knowledge, skills and efficiency in various contexts. The main drawbacks of m-health use were distraction and time wasting, difficulty in determining credibility of some online information and the risk of using these technologies inappropriately around patients and during assessments. The main facilitating conditions for m-health use were availability, quality and reliability of technological services, technical support, security, price value, technology competence and training, portability, task and goal fit, social influence and organizational factors. Habit and Hedonic Motivation were the only significant factors that explained intention to use m-health and actual m-health use respectively in the UTAUT2 model, in the presence of age, gender and experience. Students, staff and faculty members were open to using m-health in teaching and learning, although they recommended regulation of use through policies and guidelines to ensure effective teaching and learning and ethical m-health use. Considering the benefits offered by m-health, the study encourages medical schools in Ghana to explore mobile learning with the possibility of incorporating it into their curricula. This should be accompanied by development of policies and guidelines to spell out how mobile technologies should be used in order to mitigate most of the drawbacks identified. This study contributed empirical evidence from the Ghanaian context regarding m-health adoption and use in medical education. This evidence will contribute to theory regarding benefits, drawbacks, facilitating conditions and factors that influence m-health adoption among medical students in a developing country context. Understanding how medical students use mobile technology in learning will be useful in planning how m-health can be incorporated into their

curricula. It will also help in informing development and deployment of m-health in healthcare in contexts similar to Ghana.

Keywords

m-health, mHealth, e-health, eHealth, m-learning, mLearning, technology adoption, technology acceptance, technology use, medical education

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List of Abbreviations

ACM	Accra College of Medicine
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
AU	Active Use
AVE	Average Variance Explained
BC	Behavioral Control
BDS	Bachelor of Dental Surgery
BI	Behavioral Intention
BNF	British National Formulary
BUP	Botswana-University of Pennsylvania Partnership
CA	California
CBA	Controlled Before-After study
CB-SEM	Covariance-Based Structural Equation Modeling
CD	Compact Disc
C-DAC	Centre for Development of Advanced Computing
CHEATS	Clinical, Human and organizational, Educational, Administrative, Technical and Social framework
CHS	College of Health Sciences
CMA	Canadian Medical Association
CME	Continuing Medical Education
COAB	Cochrane Abstracts
CPD	Continuing Professional Development

CPOE	Computerized Physician Order Entry
CTC	Clinical Teaching Centre
df	Degree(s) of Freedom
EBM	Evidence Based Medicine
EBMG	Evidence Based Medicine Guidelines
ECG	Electrocardiography
EE	Effort Expectancy
EEG	Electroencephalography
EHR	Electronic Health Records
EMR	Electronic Medical Records
FAQ	Frequently Asked Question
FC	Facilitating Conditions
FDA	United States Food and Drugs Administration
FGD	Focus Group Discussion
FHMS	Family Health Medical School
FITT	Fit between Individuals, Task, and Technology framework
FOAM	Free Open Access Meducation
GEMP	Graduate Entry Medical Program
GHO	Global Health Observatory
GHS	Ghana Health Service
GMS	Ghana Medical School
GS	General Surgery
HB	Habit

Health-ITUEM	Health IT Usability Evaluation Model
HIM	Health Information Management
HIS	Health Information System
HIT	Health Information Technology
HM	Hedonic Motivation
HONcode	Health on the Net Foundation Code of Conduct
HOT-Fit	Human, Organization and Technology-Fit framework
HSREB	Health Sciences Research Ethics Board
I	Image
ICT	Information and Communications Technology
IQR	Interquartile Range
IS	Information Systems
ITS	Interrupted Time Series study
KNUST-DS	Kwame Nkrumah University of Science and Technology Dental School
KNUST-SMS	Kwame Nkrumah University of Science and Technology School of Medical Sciences
LOIC	Letter of Information and Consent
LoTi	Levels of Technology Implementation framework
MAMA	Mobile Alliance for Maternal Action
MARS	Mobile App Rating System
MBBS	Bachelor of Medicine & Bachelor of Surgery
MBChB	Bachelor of Medicine & Bachelor of Surgery
MCQ	Multiple Choice Question
MD	Doctor of Medicine

MDCG	Medical and Dental Council – Ghana
MIT	Massachusetts Institute of Technology
MoMEd	Mobile Medical Education
MoTeCH	Mobile Technology for Community Health
n.d.	No Date
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NMMU	Nelson Mandela Metropolitan University
NOSM	Northern Ontario School of Medicine
OCMD	Oxford Concise Medical Dictionary
OER	Open Educational Resources
OHCM	Oxford Handbook of Clinical Medicine
OS	Operating System
OSCE	Objective Structured Clinical Exams
OTC	Off-the-counter / Over the Counter
PDA	Personal Digital Assistant
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PI	Personal Innovativeness
PLS	Partial Least Squares
PPC	Pocket Personal Computer
PPP	Product, Project and Program
PU	Perceived Usefulness

PV	Price Value
QRCT	Quasi-Randomised Controlled Trial
RCT	Randomized Controlled Trial
SI	Social Influence
SIM	Subscriber Identity Module
SMS	Short Message Service
SN	Subjective Norm
SRMR	Standard Root Mean Square Residual
STG	Standard Treatment Guidelines
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TTH	Tamale Teaching Hospital
UCC-SMS	University of Cape Coast School of Medical Sciences
UDS-SMHS	University of Development Studies School of Medicine and Health Sciences
UGDS	University of Ghana Dental School
UGMS	University of Ghana Medical School
UG-SMD	University of Ghana School of Medicine and Dentistry
UHAS-SM	University of Health and Allied Sciences School of Medicine
UTAUT	Unified Theory of Acceptance and Use of Technology
V	Voluntariness
VIF	Variance Inflation Factor
WHO	World Health Organization

Chapter 1

1 Introduction

1.1 Background

Information and communications technology (ICT), since the advent of computers in the 1940s, has been seen to have possible useful applications in healthcare (Shortliffe & Cimino, 2006, p. 4). Arguably, the greatest benefits have only been realized in the last two decades with the mass production and uptake of increasingly more portable computing devices with rapidly increasing storage and processing capacity, as well as the increased access to and speed of the internet. Health Information Systems (HIS) have been assisting healthcare teams in capturing, processing, storing and sharing medical information, as well as guiding decision-making. These systems have been shown to reduce the cost of healthcare, enhance self-care by patients and help improve patient outcomes through more efficient use of information, as well as reduction of some medical errors (Ash, Berg, & Coiera, 2004; Knight, Stuckey, & Petrella, 2014; Koppel et al., 2005; Kristjánsdóttir et al., 2013; Wyatt & Sullivan, 2005), although some systems have been shown to create a whole new category of errors of their own.

Despite the good appeal that comes with the talk about how much HIS can help improve healthcare, the healthcare industry has been described by some as being "slow to understand information technology, slow to exploit it …, slow to incorporate it effectively into the work environment, and slow to understand its strategic importance" (Shortliffe & Cimino, 2006,). Indeed several studies have documented the underutilization of, inappropriate use of, and resistance to HIS by management and/or health professionals (Holden & Karsh, 2010). Some, on the other hand, use HIS alongside paper-based systems for practical reasons (Lærum, Ellingsen,

& Faxvaag, 2001). Holden and Karsh (2010) indicate that "the fit between IT and the clinical work system will lead intended end users to accept or reject the IT, to use it or misuse it, to incorporate it into their routine or work around it" (p. 159). In addition to this fit, sociological, cultural, financial and organizational factors interact with each other in influencing the use of HIS, and this does not exclude mobile health technologies (m-health) (Ackerman, 2000; Ajzen, Netemeyer, Ryn, & Ajzen, 1991; Greenhalgh & Stones, 2010; Harrison, Koppel, & Bar-Lev, 2007; Kaplan & Harris-Salamone, 2009; Mathauer & Imhoff, 2006; Tatnall & Gilding, 1999; Venkatesh, Morris, Davis, & Davis, 2003; Wells, Rozenblum, Park, Dunn, & Bates, 2015; Yusof, Kuljis, Papazafeiropoulou, & Stergioulas, 2008)

Medical schools are an important channel through which potential physicians and dentists can be introduced to the use of health IT including m-health technology with the hope that they will continue using them after entering into professional practice. Understanding how these students use mobile communication devices can be useful in informing development and deployment of m-health and planning how m-health can be incorporated into their curricula.

1.1.1 Health needs & access to health care

When it comes to healthcare, marginalized and underserved populations can be found in every country. Given (2008) describes marginalized populations as "those excluded from mainstream social, economic, cultural, or political life" for reasons such as but not restricted to "race, religion, political or cultural group, age, gender, or financial status" (para. 1). When people get marginalized in terms of healthcare, they inevitably end up being underserved or at worst un-served by the mainstream health system. Being underserved refers to

> an increased likelihood that individuals will, because of their membership in a certain population: experience difficulties in obtaining needed care; receive less, or a lower standard of care; experience differences in treatment by health personnel; receive treatment that does not adequately recognize their needs; or, be less satisfied with health care services" (Health Canada, 2001).

Healthcare service, for the purpose of this study, refers to people, programs and organisations that provide healthcare to the population (Hay, Varga-Toth, & Hines, 2006). Underserved populations vary greatly in terms of characteristics of the people that form those populations, as well as their environment. Broadly speaking, they can be viewed as being of two kinds – rural and urban. Within each of these types of underserved populations, one may find many sub-groups. Among the rural underserved for example, there are people of all ages and of varying physical and cognitive abilities living in communities or in isolation such as on homesteads. Similarly, among the urban underserved are people of all ages and of varying physical and cognitive abilities, with proper accommodation or not, street youth, immigrants (both legal and illegal), and more.

To this day, when many people in government, healthcare professionals and other stakeholders in the healthcare industry such as insurance, pharmaceuticals, biotechnology, equipment providers and the public at large talk about health, they are generally referring to medical care (Sowada, 2003). The World Health Organisation (WHO) defines health as being a state of "complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization [WHO], 2006). The use of the word "complete" suggests totality, leading one to ask, who determines how complete a person's state of well-being is? Is it the individual him or herself, or is it having medical examination results that show that nothing is wrong? Considering how biomedical standards for medical case definitions change with time as new discoveries are made, a person who is probably classified as “healthy” today, might, according to those same biomedical test results, be classified as “unhealthy” a few years later. A typical example of this is with the change in definition of overweight and obesity. Up until June 1998, a woman who was 5-feet, 4-inches (160-cm) tall was considered overweight if she weighed 70-Kg (155-lb) and above. However, when this threshold was lowered to 66-Kg, upon approval of new guidelines by the National Institutes of Health (NIH), USA, thousands, if not millions of people became reclassified as overweight overnight (Cohen & McDermott, 1998). Similarly, in June 2013, obesity was redefined as a disease in the US, making millions to be officially classified as diseased (Howell, 2013). Another problem with this definition of health is the notion of well-being. Again, who defines well-being? Is it the autonomous individual or the healthcare establishment? Combining “complete” with “well-being” can lead one to easily classify aged persons, with a chronic disease and impaired physical ability, for example, as being unhealthy although their state of health might be consistent with aging (Von Faber et al., 2001). These people might be able to exercise a great degree of independence, cope very well with their physical and mental states, and perform their social functions very well (Huber et al., 2011).

The understanding and definition of health, based on which agencies formulate policies, has long-running implications for the health needs of populations. A realistic context-specific understanding and definition of health is very important in order to accurately understand and address the health needs of various subgroups in a population, such as the underserved. Several proposed revisions to the WHO definition have been put forward over the years, popular among which is that found in the Ottawa Charter for Health Promotion, formulated almost three decades ago. According to the Charter, the basic prerequisites for health are peace, shelter, education, food, income, a stable eco-system, sustainable resources, social justice, and equity (WHO, 1986). Since its formulation, the global dynamics of disease have changed. For example, the prevalence of chronic diseases is on the rise across the globe (Wang, Mi, Shan, Wang, & Ge, 2007; WHO, 2011). An increasing middle-class population, coupled with advancing aviation technology means that more people travel across the world than before, and they do so faster. This is influencing some disease transmission patterns such as those for SARS, H1N1, H5N1, MERS and Ebola, leading to more rapid evolution of epidemics in one country into global pandemics (Tatem, Rogers, & Hay, 2006). ICT has developed at high speeds, and with it has come on one hand, widely proclaimed health aides such as medical decision-support systems and millions of mobile health apps that monitor health indices such as heart rates, quality of sleep and amount of exercise, and give information about how to manage one's health. On the other hand, however, technology has introduced new problems such as barriers to health information and health problems associated with video game, internet and social media addiction. Despite these issues, the Ottawa Charter's definition of the basic building blocks of health can be a very useful starting point in addressing the health needs of the underserved in both developed and developing countries.

While seeking and after attaining the prerequisites for health, most people will need to use healthcare services, despite their different levels of access to these services. Access is defined as "the opportunity or ease with which consumers or communities are able to use appropriate services in proportion to their needs" (Levesque, Harris, & Russell, 2013, p. 1). In

Canada, several barriers to equitable access to the healthcare have been identified and can be categorized into two—patient and system barriers. Patient-related barriers include health literacy, cultural beliefs and norms; language; cost of transportation; time off work for appointments; access to child care; payment for medications, medical devices, treatments; immobility (due to physical disabilities, and/or mental health barriers) and cognitive issues (e.g. dementia, that adversely affect ability to access and comply with care). System-related barriers include lack of health management and/or services in areas of need; lack of family physicians for patients; long wait times; mismatch between health financing models and patient needs; coordination between primary and speciality care as well as between healthcare and community services; standardization of referrals and access to specialists and social services; lack of needs based planning; prejudice, discrimination and overall attitudes of health care workers; and jurisdictional ambiguities (Canadian Medical Association, 2013; Health Canada, 2001; National Collaborating Centre for Aboriginal Health, 2011). While the problems mentioned above are based on the Canadian context, they resonate well with developing countries such as Ghana, a West African county with a population of about 25 million, of which about 51% live in urban centres (Ghana Statistical Service, 2012). In Ghana, underserved groups often cope with these barriers by relying on a combination of family and friends, first-aid guides, folk medical knowledge handed down through generations, and pharmacists/pharmacy attendants (where available) for health information. Similarly, underserved populations in other countries often use off-the-counter (OTC) medications and natural remedies for relieving minor illnesses, have to travel long distances to access emergency services, or have to relocate to towns with health facilities temporarily (Sulemana & Dinye, 2014; Wathen & Harris, 2007).

Several recommendations have been made in the academic literature and reports commissioned by governments, advocacy groups and health organisations, such as the WHO, regarding how to reduce underservice for underserved populations. Prominent among these are the ideas that ICTs can be used for improving communication within health teams and between health professionals and patients, improving health literacy among patients and the public at large, and providing some health services to remote locations (Diamond & Roberts, 2012; Health Canada, 2001). Wireless mobile technologies have not been left out of this new direction. It is not surprising therefore that the Canadian government and private Canadian donors have spent around $8 million on m-health projects globally (Shuchman, 2014).

1.1.2 m-health

It is broadly accepted that m-health is a subdivision of e-health which is “the use of ICT for health” (WHO, 2011, p. vi). However, how m-health is defined keeps changing with time and as one moves from academic to gray literature. This is not surprising considering how rapidly wireless mobile technology is evolving and its uptake soaring.

According to Siau and Shen (2006), m-health is the “development, dissemination and application of mobile information and wireless telecommunication technologies in the area of healthcare” (p. 90). While this early definition sought to capture the entire process of development, distribution and use of mobile technologies for healthcare, more recent definitions have been centered on use. Qiang, Yamamichi, Hausman, Altman, and Unit (2011) define m-health as “any use of mobile technology to address healthcare challenges such as access, quality, affordability, matching of resources, and behavioural norms” (p. 15). Tamrat and Kachnowski

(2012) define m-health as "the integration of mobile telecommunication and multimedia into increasingly mobile and wireless health care delivery systems" (p. 1092). These two definitions seem to link m-health only to the healthcare system and neglect the wider understanding of health, which includes roles that individuals play in various ways to maintain or improve their own health. While mobile technology may indeed be used in attempts to solve health-related challenges, a casual scan of today's m-health landscape shows that seemingly healthy people use mobile health technologies for various reasons other than overcoming challenges with the healthcare system. Common uses include monitoring various health indices, for example, sleep quality, heart and breathing rates, and amount of physical activity. Another definition, while acknowledging the use of mobile technologies for health-related purposes in general, restricts the concept to only mobile phones. Betjeman, Soghoian and Foran (2013), define m-health as "the use of mobile phone technology for health-related purposes" (p. 1).

The word "mobile" connotes a sense of freedom and flexibility to use the technology anywhere and at any time, free of the restrictions that come with using devices that are fixed to a particular location. Broadly, mobile technology in healthcare would also include any portable device carried along by patients or health professionals and operated from anywhere and at any time with or without communication capabilities. However, being a subset of e-health, m-health would exclude devices without communication capabilities. For the purposes of this study, m-health refers to mobile communication technology used for health-related purposes. As such, a glucometer capable of sharing blood glucose measurements with a patient's physician or electronic medical records would count as m-health technology. Laptops, tablet computers, cellular phones, smartphones, personal digital assistants (PDAs), vehicle navigation devices and pagers would all count as m-health. Combining the words “m-health” with “technology” seems to be somewhat of a misnomer since the very definition of m-health states that it is technology. However, whenever the term is used in this way, it will refer to m-health products such as devices, apps or computer programs. Figure 1.1. illustrates what features come together to make m-health.

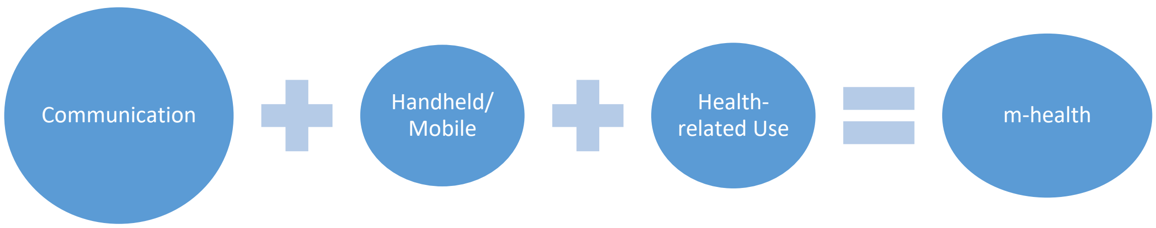

Figure 1.1: Main features that make up m-health

Many countries, both in the Global North and South, are contending with shortages in health professionals. According to the WHO, in 2013 there was a shortfall of 7.2 million health workers globally and this is set to reach 12.9 million by 2035 if nothing is done to improve the situation (WHO, 2013). While for some countries these shortages are nationwide, for others, there are disparities between different regions within those countries. Typically, urban areas would have ample numbers of health professionals while rural areas and areas of less socio-economic activity would have shortages in different classes of health professionals. This is confirmed by the WHO. “In the Americas, 70% of countries have enough health care workers to carry out basic health interventions, but those countries still face significant challenges linked to the distribution of professionals, their migration and appropriate training and skills mix” (WHO, 2013, para. 8).

The last decade has seen a massive proliferation of mobile telecommunications across the globe, driven in part by the expanding availability of high-speed internet, and a drive by phone manufacturers, operating system developers and telecom service providers to offer smartphones cheaply. There are as many mobile phones in the world as there are people (Boren, 2014). Mobile phone accessibility in developing countries has exceeded computers and health infrastructure (Vital Wave Consulting, 2009). The middle-class is growing rapidly in many developing countries (Kharas, 2010; Ravallion, 2010) and with this has come a growing demand for gadgets such as smartphones, tablets and other hand-held communication devices. Another reason said to account for the surge in smartphone use is the unique ability of having personalized and location-based services. Mobile phone service (voice, text and data) is also getting increasingly cheaper for consumers, with some service providers in countries such as Ghana, India and Zambia offering free data packages to access selected websites such as Facebook, Wikipedia and MAMA (Mobile Alliance for Maternal Action), and apps such as WhatsApp and WRAPP (Women's Rights App) (Airtel India, 2015; Hicks & Murlidhar, 2010; Internet.org, 2014; Myjoyonline.com, 2015). Mark Zuckerberg, founder of Facebook in April 2015 announced the expansion of the Internet.org initiative beyond developing countries to provide free internet access in Europe too (Griffin, 2015). In many sub-Saharan countries such as Ghana, Kenya, Nigeria, Tanzania, Uganda and Malawi, text-message-based banking has become the mainstream cashless transaction system. Clearly, mobile technology has proved itself to be disruptive in sub-Saharan Africa. It is time to leverage this disruptive technology to help improve access to healthcare and health information, as well as improve management of medical information and access to the latest medical knowledge for health professionals

Even so, the wide penetration of mobile phone technology does not mean that everyone on the globe owns a mobile phone or that his or her mobile device would support every available service. It is not rare to find people that do not own a mobile phone. The number of people that do not have access to a mobile phone is much less than those who do not own phones themselves because it is commonplace, especially among low income groups, for people to rely on someone else's phone, such as that of a family member or neighbour, for sending and receiving important messages (Aker & Mbiti, 2010; James & Versteeg, 2007). The wide access to, and flexibility of mobile technology, coupled with problems of inadequacies in the healthcare systems of many countries are the main points put forward by proponents of m-health for its promotion (Akter & Ray, 2010; Diamond & Roberts, 2012). In fact, many other industries have already leveraged mobile technology to provide services such as banking, e-commerce, food price monitoring, weather monitoring, and media streaming.

1.1.3 Types & uses of m-health

M-health is being applied at various levels in the healthcare continuum—patients, health professionals and administrators. Based on the type of technology or feature employed, m-health can be categorized into SMS based, voice based, mobile sensors, or apps for smartphones and other mobile computing devices. In terms of use, m-health technologies have been classified in different ways, although for the most part, these classifications are similar. Table 1.1 below positions some of the classifications used in literature relative to each other. The table shows to some extent, the degree of overlap between categories. This is not surprising considering that some m-health technologies perform more than one function. For example, many decision-support systems used to aid diagnosis and treatment also collect patient medical records.

Furthermore, some of the functions are interrelated. For example, there is a clear link between education and awareness creation on one hand, and communication among and between health workers and patients on the other. The latter (i.e., communication) could be a means of achieving the former (i.e., education and awareness creation) in addition to simply describing the exchange of information required for the performance of work among health workers and between them and patients.

Table 1.1: Classification of m-health technologies

Source	**Classification Categories**						
	Disease & Epidemic Surveillance	**Data Collection**	**Diagnosis & Treatment**	**Health/ Administrative Systems**	**Remote Monitoring & Compliance**	**Information, Education & Awareness**	**Communication**
Vital Wave Consulting (2008, p. 13)	Disease/ Emergency Tracking	Data, Health Record Access	Analysis, Diagnosis & Consultation	Health/ Administrative Systems	Monitoring/ Medication Compliance	Education & Awareness	
Vital Wave Consulting (2009, p. 9)	Disease and Epidemic Outbreak Tracking	Remote Data Collection	Diagnostic & Treatment Support		Remote Monitoring	Education & Awareness	Comm. & Training for Healthcare Workers
Blynn (2009)	Data Collection and Disease Outbreak Surveillance		Diagnostic Treatment and Support		Drug Adherence and Remote Monitoring	Information Dissemination	
Akter & Ray (2010)	Disease & Epidemic Outbreak Tracking	Remote Data Collection	Diagnosis & Treatment Support		Remote Monitoring	Education & Awareness	Comm. & Training
Mechael, Batavia, Kaonga, & Searle (2010)	• Data Collection and Disease Surveillance • Emergency Medical Response	Health Information Systems and Point-of-Care Support Tools for Health Workers			Treatment Compliance	Disease Prevention and Health Promotion	
Labrique, Vasudevan, Kochi, Fabricant, & Mehl (2013)	Registries/ Vital Events Tracking	• Data Collection & Reporting • Electronic Health Records	• Sensors & Point-of-care Diagnostics • Electronic Decision Support	• Provider Work planning & Sched. • Human Res. Mgt. • Supply Chain Mgt. • Financial Transactions & Incentives	Sensors & Point-of-care Diagnostics	• Client Edu. & Behaviour Change Comm. • Provider Training & Education	Provider-to-provider Comm.

The m-health landscape is vast and constantly changing. While many m-health products, projects and programs (PPPs) are launched every year, many others fail within the same timespan. Owing to this, it is nearly impossible to document all PPPs at any given time.. Since many m-health technologies perform more than one function, it is quite difficult to organise them neatly into Table 1.1. Users of the m-health technologies comprise patients, healthcare workers, public health workers and the public. The m-health technologies have been piloted and/or are being used in both urban and rural settings and target the underserved, at-risk groups and the general population. M-health interventions have been piloted and/or are in use for chronic and infectious diseases as well as mental health and health promotion (Hamine, Gerth-Guyette, Faulx, Green, & Ginsburg, 2015; Knight et al., 2014). While some of the m-health tools were developed for specific diseases, interventions and settings, others were more generic in nature, allowing for easy customization and adaptation to the objectives at hand.

1.2 Research Problem

There is a challenge with health care access in most developing countries, as determined by measures such as health personnel-patient ratios and proportions of child births attended by qualified health personnel (WHO, 2016). Health care professionals such as physicians have a significant role to play if m-health is to be successfully leveraged in helping to address this challenge. While some health professionals resist health information systems (Bhattacherjee & Hikmet, 2007; Doolin, 2004; Gonzalez & Chan, 2013; Holden & Karsh, 2010; Samhan & Joshi, 2015), others have been found to use paper-based records alongside electronic records systems (Lærum et al., 2001). Some of these problems could be addressed if such systems, including m-health, are introduced to health professionals while they are in school. Introducing m-health to medical students while in school could help to ensure m-health were used appropriately later on in professional practice (Broom, Adamson, & Draper, 2014; Fuller & Joynes, 2015). Mobile technology could enhance learning in the educational setting though mechanisms such as providing instant access to course materials and additional resources available on the web and on devices, facilitating both personalized and collaborative learning, enabling users to effectively organize knowledge, and facilitating access to and interaction with instructors and mentors beyond the classroom or ward (Motiwalla, 2007). However, there is limited research about how medical students use m-health technology in learning in Ghana.

1.3 Study Context

Ghana is a small middle-income West African country with an estimated population of 29 million (The World Bank, n.d.). According to the World Health Organization, there were 10 doctors per 10,000 people in 2012 (WHO, n.d.). This was a stark decline from 16 doctors per 10,000 people reported in 2004. This could be attributed to a steady population grown rate of about 2.5% per annum over the last three decades (The World Bank, n.d.) without a matching increase in the number of doctors trained. Some doctors may also be leaving the country for better opportunities abroad. It is only in the last decade that new public and private medical schools have been established to help amend the situation. Without comparing Ghana's doctor-patient ratios to those of countries in the

Global North, the decline alone is evidence of a gap in access to health care and possibly, health information, which m-health can help to mitigate. According to WHO, there were 101 cellular phone lines per 100 people in 2012 (WHO, n.d.).

1.3.1 Educational resources in higher education in Ghana

There are 17 public universities, 9 public professional institutes and about 40 private colleges in Ghana. Although there are libraries in each of these institutions, with the older public universities having the largest collections of materials, there is a problem of keeping these collections up to date. Several years ago, ICT was identified as the biggest threat to academic libraries in Ghana (Martey, 2000). Some researchers urged academic libraries to embrace it and shift focus from ownership of collections to access to collections, instead of resisting ICT (Amekuedee, 2005). Indeed, they did, as I observed during visits to some public universities in Ghana.

Open Educational Resources (OER) are playing a significant role in this regard. The William and Flora Hewlett Foundation, chief sponsors of the OER Africa initiative define OER as "teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions" (William and Flora Hewlett Foundation, n.d.). Established in 2008, the OER Africa initiative has a vision to facilitate the creation of "vibrant and sustainable African education systems and institutions that play a critical role in building and sustaining African societies and economies through free and open development and sharing of common intellectual capital" (OER Africa, n.d.-a). A study conducted at the University of Lagos, Nigeria, found that although students had limited understanding of what OER represented, they had positive attitudes to them and benefitted from them in several ways beyond completion of academic work (Onaifo, 2016).

Another collection of resources that academic libraries in Ghana have embraced to help them provide relevant services to their clients is Hinari. The Hinari Programme was established by the WHO in partnership with major publishers, to make journals, books and other information resources available to educational, health and other non-profit institutions in the Global South for free or at a small fee (World Health Organisation, n.d.).

With online resources such as OER Africa and Hinari, and with smartphones and tablets increasing in speed and storage capacity, students have found it convenient to engage in mobile learning. Not only does it save them from buying books, they are able to carry the contents of several heavy books on their smartphones, tablets or laptop computers.

1.3.2 Medical education in Ghana

Medical training programs differ across the world. This is expected since health care systems differ and so do distributions of morbidity and mortality. Medical education may be broken down into three stages: undergraduate medical education, graduate medical education and continuing professional development. This study focuses on undergraduate medical education, details of which are provided in the paragraphs that follow. Graduate medical education refers to programs leading to specialization in any of the fields. Continuing professional development refers to approved knowledge and skills improving activities undertaken by practitioners (Medical and Dental Council - Ghana [MDCG], 2015, p. 2).

Undergraduate medical education refers to programs leading up to the award of Bachelor of Medicine and Bachelor of Surgery (MBChB/MBBS), Doctor of Medicine (MD), or other similar degree (College of Medicine, University of Ibadan, n.d.; National Center for Biotechnology Information, U.S. National Library of Medicine, n.d.; University of Ghana, 2015, pp. 120-128). Some programs (sometimes called traditional programs) admit student from high school and last six to seven years, while others (mainly in North America) admit students with previous undergraduate degrees into four-year medical programs (Anderson & Kanter, 2010; Ellaway, Fink, Graves, & Campbell, 2014). Mostly in traditional programs, the first few years are dedicated to pre-clinical courses, while the remaining years are used for clinical training (University of Ghana, 2015, pp. 31, 120). In some four-year programs, students may be introduced to clinical courses as early as their very first semester (Anderson & Kanter, 2010). This study is looking at undergraduate medical education because this is the stage at which students are first immersed into the knowledge and culture of the medical profession. This is the earliest stage at which the use of ICTs in medical care can be introduced to future doctors.

There are seven medical schools in Ghana, namely, Accra College of Medicine (ACM), Family Health Medical School (FHMS), Kwame Nkrumah University of Science and Technology (KNUST) School of Medical Sciences (KNUST-SMS), University of

Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine and Health Sciences (UDS-SMHS), University of Health and Allied Sciences School of Medicine (UHAS-SM) and University of Ghana School of Medicine and Dentistry (UG-SMD).

Accra College of Medicine was established in 2013 with the aim of training more doctors to supplement the turnover of about 400 doctors produced per year by the four public medical schools in the country at the time. The school runs a six-year medical program with entry open to both undergraduate and graduate students. The school expects to produce its first doctors in 2020. An examination of its curriculum shows that there is no ICT competency course or formal training on the use of HIT as part of its medical program (Accra College of Medicine, n.d.). Considering that this school had no students in clinical years at the time of data collection, it was excluded from this study.

Family Health Medical School (FHMS) is also a privately-owned medical school based in Accra. Its first intake of students took place in March 2016. The school offers a six-year medical program leading to the award of MBChB degree (Family Health Medical School, 2016). At the time of data collection, FHMS did not have clinical year students, so the school was excluded from the study.

Kwame Nkrumah University of Science and Technology (KNUST) School of Medical Sciences (KNUST-SMS) was established in 1975 (Kenu, 2016). It offers a seven-year medical program comprised of a four-year BSc Human Biology (Medicine) program, followed by a 3-year clinical program leading to MB ChB Degree (KNUST undergraduate programs, n.d). In the last few years, the number of students graduating from the school has increased steadily from 90 in 2011 to 104 in 2013 and 176 in 2016 (Modern Ghana, 2011; Obour, 2013; University Relations Office - KNUST, 2016). KNUST-SMS is situated under the university's College of Health Sciences. Located in Ghana's second largest city Kumasi, the school is affiliated with the Komfo Anokye Teaching Hospital, the regional referral hospital for the Ashanti Region. KNUST also participates in the OER program, and as is the case with UG-SMD, produces videos, images, PDF files, etc. for students, which it stores in an institutional repository, that is shared with partner institutions.

University of Cape Coast School of Medical Sciences (UCC-SMS) started in 2008 with 43 students (Moden Ghana, 2008). The school runs a six-year medical program leading to the award of MBChB degree. There are accommodations for students with degrees in the health sciences to be exempted from enrolling into the first year or two. The first doctors from UCC-SMS graduated and were sworn into the profession in 2013. Forty-two students graduated in 2015 while 56 graduated in 2016 (Addo, 2016; Asiedu-Addo, 2015). The school is affiliated with the Cape Coast Teaching Hospital, where clinical year students undergo their clinical training. Attached to the hospital is the School of Medicine Clinical Training Centre that contains a library, lecture halls and offices for instructors to cater for the training needs of clinical year students.

University of Development Studies School of Medicine and Health Sciences (UDS-SMHS) offers a six-year medical program leading to the award of MBChB degree, in addition to other programs. The school is located in Tamale, capital of Northern

Region and is affiliated to the Tamale Teaching Hospital. In 2012, 27 doctors graduated from the school (Modern Ghana, 2012) while in 2015, 33 doctors graduated (Naatogmah, 2015). For the 2014/2015 academic year, 122 students were admitted into the medical program (Naatogmah, 2015).

The University of Health and Allied Sciences School of Medicine (UHAS-SM) was established in 2012 to train doctors and physician assistants (Tagbor, 2017). The school runs a six-year MBChB program. In September 2017, the school held its first white-coat ceremony to usher students into their first clinical year (University of Health and Allied Sciences School of Medicine, 2017). UHAS-SM is located within the Ho Teaching Hospital, which used to be called the Volta Regional Hospital prior to its elevation to teaching hospital status in 2015.

The University of Ghana School of Medicine and Dentistry (UG-SMD) is located within the Korle Bu Teaching Hospital in Accra, Ghana. Korle Bu is the largest hospital in the country and receives only referrals and emergencies. There is a walk-in polyclinic attached to the hospital that takes care of medical needs of the surrounding community. The school started as Ghana Medical School (GMS) in 1964 and has undergone various structural transformations, the most recent of which is the combination of University of Ghana Medical School (UGMS) with the University of Ghana Dental School (UGDS), to become the University of Ghana School of Medicine and Dentistry in 2014. This is one of six schools/institutes under the College of Health Sciences (CHS) of University of Ghana. The school has 3 programs namely Bachelor of Medicine & Bachelor of Surgery (MBChB) Program, Graduate Entry Medical Program (GEMP) and Bachelor of Dental

Surgery Program (BDS). The MBChB and BDS are awarded to undergraduate students who successfully complete a three-year pre-clinical component leading to the award of Bachelor of Science Medical Science (BSc. Med. Sci.) degree, followed by a three-year clinical component in the respective programs (University of Ghana, 2015, pp. 120, 128). Much like the medical education system in North America, GEMP is a four-year graduate entry program leading to the award of an MBChB degree. In 2014, 156 doctors were awarded the MBChB degree, while 21 dentists received their BDS degrees (Vibe Ghana, 2014). The GEMP program has an annual intake of about 50 students (University of Ghana, 2016)

With the exception of a biostatistics course in which students are taught computer skills for data management and analysis, there is no formal training on the use of health information technology (HIT) as part of the MBChB, GEMP or BDS programs. Furthermore, competency in HIT use is not a requirement for the award of degrees (University of Ghana, 2015, p. 129). These might be explained by the fact that the National Health Service does not have a national electronic health records (EHR) system. EHR use is therefore restricted to only a few privately-owned health facilities. The CHS established an OER office in 2008, tasked with digitizing learning resources in the form of videos, images, PDF files, etc., and sharing this with partner universities participating in the OER Africa program. Most importantly, the office is there to ensure students had real-time access to the multitudes of electronic learning materials from partner universities. In 2011, UGMS established its eLearning Committee, to help speed up digitization and organization of learning materials. This committee included members from the OER office. Materials are available to students in the form of videos, images, PDF files and self-assessment quizzes via the college's OER portal and on the OER Africa website (OER Africa, n.d.-b).

In Ghana, the Medical and Dental Council is the body mandated by law—the Health Professions Regulatory Bodies Act, 2013 (Act 857)—to ensure that training standards for physicians, dentists, physician assistants and certified registered anaesthetists are adhered to by educational institutions, to prescribe and enforce professional standards for the health professionals and to examine and register the health professionals (Medical and Dental Council - Ghana [MDCG], n.d.). After initial registration, health professionals are required to remain in good standing by renewing their registrations every year. Since 2009, this renewal of registration has been contingent upon participation in continuing professional development (CPD)— "any educational activity which helps to maintain, develop or increase knowledge, problem-solving, technical skills or professional performance standards all with the goal that practitioners can provide better health care" (MDCG, 2015, p. 2). Among the list of approved programs for physicians and dentists are e-learning under which telemedicine and webinars are mentioned, and IT training with specific mention of computer assisted clinical programmes.

1.4 Research Purpose & Significance

The purpose of this study is to find out how clinical year medical students use m-health in school and with what outcomes. In view of the many benefits that m-health (including m-learning) has been said to provide, and the potential to be counterproductive to learning and clinical work, it is important to understand how clinical year students use mobile technology and the outcomes associated with this use.

This study will contribute evidence from Ghana regarding the use of m-health by medical students. Knowledge generated from this study might be useful in aiding in the development of effective modes of introducing e-health and m-health into medical curricula, as well as medical practice.

1.5 Research Objectives

This study is aimed at investigating how students in clinical years of undergraduate study in medical schools in Ghana are using m-health for learning and practice. The main study objectives are:

(a) to collate the types of ICTs that students have access to,

(b) to collate the types of m-health that students are using, and contexts in which they are used

(c) to investigate the uses of m-health by students,

(d) to investigate the impact (benefits & drawbacks) of m-health use by students,

(e) to investigate the enablers and barriers to m-health use by students (facilitating conditions),

(f) to investigate factors that predict and explain m-health adoption and use,

(g) to investigate the attitudes of medical students, faculty members and institutional staff towards the use of m-health in teaching and learning.

1.6 Research Questions

The study will be guided by the following research questions:

1) Types and uses of ICT and m-health, and the contexts within which they are used:
    a) What types of m-health are being used by clinical year undergraduate medical students for learning and clinical training in Ghana?
    b) What activities do clinical year undergraduate medical students in Ghana use m-health for?
    c) How do clinical year undergraduate medical students in Ghana find out about new m-health technology?
    d) Does the frequency of m-health use depend on the learning context?
2) Impact of m-health (benefits and drawbacks)
    a) What are the benefits of using m-health for learning and clinical training among clinical year undergraduate medical students in Ghana?
    b) What are the drawbacks of using m-health for leaning and clinical training among clinical year undergraduate medical students in Ghana?
3) Facilitating conditions (enablers and barriers) for m-health use
    a) What enablers are associated with m-health use by clinical year undergraduate medical students in Ghana?

b) What barriers are associated with m-health use by clinical year undergraduate medical students in Ghana?

c) What are the effects of significant social influence on m-health use by clinical year medical students in Ghana?

d) How do clinical year undergraduate medical students in Ghana cope with barriers of m-health use for learning and clinical training?

e) What factors predict and explain intention to use m-health and current m-health use?

4) Attitudes towards m-health use:

a) What are the attitudes of clinical year undergraduate medical students in Ghana, towards the use of m-health technology in learning and providing care?

b) What are the attitudes of school key institutional staff members towards the use of m-health by clinical year undergraduate medical students in Ghana?

c) What are the attitudes of faculty members towards the use of m-health by clinical year undergraduate medical students in Ghana?

Chapter 2

2 Literature Review

This chapter discusses factors known to be associated with the use of technology in the workplace and presents a conceptualization of mobile learning. It then reviews the impact of m-health and examines key studies on the use m-health in medical education. Lastly, it looks at mobile learning in other sectors.

2.1 Enablers of technology use

Researchers have identified several factors that influence the use of technology in work-related activities. These factors can be categorized into technology, user, social and organizational. In a sense, medical training can be considered as work for two reasons. First and most obvious, in clinical years, students are engaged in attending to patients, although under supervision. Second, the very process of mental and physical exertion required to obtain the reward of a degree in medicine or dental medicine would make that pursuit analogous to work.

Technology-centered factors

Among the technology-related factors that make a new technology more likely to be used are system reliability, sociotechnical and occupational fit, and user-friendliness.

First, a system needs to work for users to use it. It may be very difficult for users to appreciate the value of a system if it turns out to be unresponsive at times, is unable to retrieve stored information, or parts of it do not function well e.g. buttons and commands.

System reliability is a basic requirement that needs to be assured before any other factors can come into play in determining whether or not people will use any technology.

In order to facilitate easy adoption and continuous use, new technologies need to fit the work environment, processes and goals. Currently, there is no clear evidence about the best approaches for introducing new technology into work settings such as healthcare. With the huge amount of interest by researchers, governments, non-profit and private commercial entities to introduce technologies to aid work, the health information systems (HIS) landscape has found itself filled with many software programs and devices that focus on improving the performance of individual tasks rather than aiding team-based processes (Walker & Carayon, 2009). This has led to fragmentation and high costs of care in the US for example (p. 468). In certain occupations that thrive on individual work, task-oriented technologies might be perfect. It is important that technology development involves a core understanding of how people really work in both the broad sense and in finer details so that new technologies do not cause more problems than they are meant to fix (Ackerman, 2000).

User-friendliness is another important feature that new technologies need to have in order to keep people using them (Ahmad et al., 2002; George, Garth, Fish, & Baker, 2013). Desktop programs, apps and devices must be easy to use, and this can be achieved by having a good understanding of the nature of work that users perform. For students seeking information urgently, or health workers in high paced environments, speed and accuracy of information retrieval will be paramount. For work environments that involve sharing of tasks, rather than trying to squeeze every single function of a program on the same screen, developers may for example use a modular design and present only the functions that workers would need to use in their roles. Disruption of routine workflow and a resulting loss of productivity can lead to diminished use (Campbell, Guappone, Sittig, Dykstra, & Ash, 2009). Users may come up with workarounds such as batch processing of tasks, with possible far-reaching effects on patient care.

User-centered factors

Among the user factors that might make a new technology more likely to be adopted include self-perceived and actual IT knowledge and personal innovativeness.

Self-perceived IT knowledge has been shown to be a very important factor when people start using any new technology. People with high self-perceived IT knowledge, are more likely to start using new technology and do so faster (Aggarwal, Kryscynski, Midha, & Singh, 2015). People with low actual IT knowledge were found to discontinue use of new technology faster than those with high actual IT knowledge (Aggarwal et al., 2015). These findings can be helpful in explaining long term use of technology. A study at a medical school in Ghana found that almost 90% of students had average to advanced knowledge of basic computer programs (Achampong & Pereko, 2010). Furthermore, while males showed better knowledge and skill with computer programs, females used the internet more frequently.

Personal innovativeness is another factor that has been identified as contributing to technology uptake. It refers to an individual's willingness to try out a new technology (Lu, Yao, & Yu, 2005). Studies have shown that people with more of this trait are better at information seeking, cope with uncertainty better and tend to have more positive attitudes towards acceptance (p. 251).

Social Factors

Social influence also plays an important role in technology use. Studies have shown that where users feel that significant social connections such as faculty members in this case and colleagues expect them to use a particular technology, they are more likely to use it (Lu et al., 2005; Venkatesh et al., 2003). Furthermore, after a critical mass of people begin using a particular technology, a domino effect occurs whereby others hasten to start using the technology (Kaminski, 2011). Several reasons may account for this, including explanations that the value of that technology becomes more widely known, non-users do not want to be left behind (image) and there might be more social support to help those who encounter challenges (Gonzalez & Chan, 2013; Lu et al., 2005). With this and the previous point in mind, having technology-savvy faculty members and students leading the way as first adopters and providing support and encouragement to others can be helpful in getting m-health and m-learning technologies to spread in educational settings (George et al., 2013).

Organizational Factors

Financial incentives are very important in encouraging the implementation of health information systems in health facilities (Wells et al., 2015). Depending on the size of a health facility, implementation of an electronic health records system (EHR), for example, may involve significant costs related to the purchase of EHR program, security programs, personal computing devices on which to run those programs such as desktop, laptop and/or tablet computers, network infrastructure (computer servers, routers, cables and access points), internet service, and IT staff (George et al., 2013). These costs might be burdensome for some health facilities and teaching hospitals to bear, especially when it is not clear if the investments will be recovered. It is therefore no surprise that in some countries such as the United States, the government offers financial incentives to help cushion health facilities and encourage them to adopt EHRs (Baier et al., 2012; Worzala, 2009). The government of the United Kingdom on the other hand, procured an EHR system for nationwide deployment (Cresswell, Worth, & Sheikh, 2012). In some medical schools that have formal e-learning and m-learning programs, devices and programs have either been provided to students as part of the fees paid or students have been asked to purchase devices as part of their learning materials (Ellaway et al., 2014; Jackson, Ganger, Bridge, & Ginsburg, 2005; Maguire & Clayman, 2010; Mathis, 2011; Stanford University School of Medicine, n.d.).

With the introduction of any new technology, there are bound to be glitches and teething problems. Technology use is likely to diminish if these issues are not dealt with in timely and satisfactory manner. Examples of such issues are tweaks to EHR systems to make them fit better with workflow, software bugs, need for further training, devices and programs not working as intended, etc. (George et al., 2013). It may be difficult for users to appreciate the usefulness of systems that are not functioning as intended. It is therefore important that HIS developers and vendors become very responsive to such issues in order to ensure confidence in the systems (Ahmad et al., 2002). Having technical support readily available in health facilities and health professional training institutions can be of great use.

2.2 Barriers to technology use

Several factors have been identified as posing challenges to the use of technology. Among these are lack of awareness; security, privacy and confidentiality issues; service infrastructure (electricity, internet, cellular network); sociotechnical factors (e.g. human resource constraints, disruption of routine work by the technology, upset in power balance in the work place); and policy factors.

For users to realize the full value of any technology, they need to use it. However, it is common to find people not using technology because they are not aware of its value. This paradox calls for sustained awareness creation and training among users. A study involving textual analysis of essays written by second year medical students at the beginning of a medical informatics course in Croatia, found that most of the students had little knowledge and experience with the Croatian e-health program (Hercigonja-Szekeres et al, 2012). This was surprising given that most of the students were very familiar with internet use (p. 1152). A good understanding of the contexts in which various subgroups of users find themselves will help in developing appropriate and effective communication strategies for this awareness creation. Health professional associations are a good starting point for introducing new HIT to health professionals. However, for students in school, peers and faculty members can be an effective means of conveying this awareness.

Security, privacy and confidentiality concerns can keep people away from using any HIT, be it an EHR or freely available health monitoring app. Unauthorized access to patient information can have serious consequences on treatment outcomes, as well as their social well-being. For example, tampering with a patient's medical history can lead to wrong diagnoses and treatments, which could be life-threatening for the patient. Similarly, leakage of a patient's health status to the public could have far-reaching effects on his/her quality of life, especially if it involves a disease for which there is a significant amount of stigmatization. Various technology-related measures can be put in place such as firewalls, encryption of communications, anti-virus programs, computer access audit trails, etc. However, these do not go as far as addressing all the issues regarding privacy and confidentiality. Patients might need to know who else apart from their immediate medical team has access to the EHR data. Fear or uncertainty on the part of health professionals regarding privacy and security of patient data have been identified as a barrier to technology use (Blumenthal, 2009).

With all the data being collected about people's medical history, physical activities, vital signs, eating habits, type of health information accessed and location, m-health is contributing to the "big data" revolution in ways that health researchers have always dreamed of. Big health data are very useful not only for helping patients with the management of their illnesses, or helping people to keep fit, it is becoming an integral part of disease surveillance and policy planning. Apart from the possible cost savings that might come through m-health by reducing hospital admissions, admission times, number of unnecessary tests and investigations, choosing the best treatment options, and preventing medication errors (Canada Health Infoway, 2013; Groves, Kayyali, Knott, & Van Kuiken, 2013), big data have further economic value. New companies have sprung up and existing ones have set up big data analytics units or subsidiaries e.g. OptumInsight, HealthCore and GNS Healthcare, to collect and analyze big health data for their parent companies or others interested in their services such as pharmaceutical companies (GNS Healthcare, 2014; Groves et al., 2013; Optum Inc., 2014). Data brokers are people or organizations that profit from aggregating data about individuals from various data sources and selling that data to interested parties. Increasingly, the line between data sources and brokers is becoming murkier since some of these brokers are also collecting data directly (Couts, 2013). But one thing is certain: they have contact information and data about online habits of millions of people and may keep this information indefinitely. One of the possible implications of this is that patients with diabetes, for example, may end up paying more health insurance premiums or top-ups if their insurance companies find out that they do not comply with treatment. The commercialization of big data poses great privacy and confidentiality risks to patients and may affect their confidence in the healthcare system, particularly e-health. To collect or work with similar data, academic researchers are required to obtain ethical clearance, which commercial companies can go around because of loopholes in regulations in many countries. Countries need to develop well-thought through policies and regulations to govern management of e-health and m-health data, as well as big data in general. Although app stores can restrict access to certain apps based on one’s country, many health apps do not use this restriction and hence can easily escape laws in some countries.

Studies into user resistance of technology have shown that people sometimes resist technology because of perceived or actual threats such as loss of power by certain individuals or groups and increased workload (Bhattacherjee & Hikmet, 2007; Laumer & Eckhardt, 2012; Tang, Ash, Bates, Overhage, & Sands, 2006). In some situations, change of power balance and workload may be welcome, while in others, it may lead to resistance. For example, the introduction of a computerized physician order entry (CPOE) system may shift the responsibility for that task from nurses, unit clerks and pharmacists to the physician (Walker & Carayon, 2009). While this may reduce the workload for nurses, unit clerks and pharmacists, it may also reduce their power in the workplace.

Crucial to the effective functioning of technology is having reliable service infrastructure, specifically, uninterrupted access to electricity, internet and cellular network signals (Achampong, 2012; Mechael et al., 2010). In developed countries, these are often not significant problems except in remote areas. However, many developing countries such as some in Sub-Saharan Africa are plagued with frequent blackouts. High speed internet service and strong cellular network signals are often not available outside major cities. Without these, it will be difficult for users to realize any possible usefulness of even a simple SMS based health IT service.

2.3 Mobile learning (m-learning)

The widespread use of wireless mobile communication devices in the last decade-and-a-half (Bonnington, 2015; Columbus, 2013), coupled with the almost intuitive way in which many young people have grown up using these devices has led to a lot of interest in their use in learning. According to Yi, Liao, Huang, and Hwang (2009) mobile learning (m-learning) refers to “an array of ways that people learn or stay connected with their learning environments—including their classmates, instructors, and instructional resources—while going mobile” (Yi, Liao, Huang, & Hwang, 2009, p. 478). Based on this definition, it is easy to see that m-learning is not a new concept. Decades ago, learners used various technological affordances of their times to engage with their learning materials, environments and peers. For example, cassette recordings, compact discs (CDs) and portable MP3 players enabled access to learning materials on the go.

However, mobile learning (m-learning) is widely considered as a subdivision of e-learning (Caudill, 2007; Georgiev, Georgieva, & Smrikarov, 2004). It is, therefore, not surprising that some researchers would define m-learning in terms of existing handheld digital communication devices. For example, Kambourakis, Kontoni, and Sapounas (2004) define m-learning as “The point at which mobile computing and e-Learning intersect to produce an anytime, anywhere learning experience” (p. 1). Traxler (2007) views m-learning as a completely new paradigm in teaching and learning, and central to this is the use of mobile technology. El-Hussein and Cronje (2010) view mobile learning as an activity that supports traditional education, mediated by mobile devices. According to them, “Mobile learning as an educational activity makes sense only when the technology in use is fully mobile and when the users of the technology are also mobile while they learn” (p. 14).

Mobile learning consists of a few components: the learning environment, instructors, learners, content and assessment (Ozdamli & Cavus, 2011). The authors note that not all of these components need to be present in order for a learning activity or process to be classified as m-learning. Depending on whether an educational institution has a formal m-learning program or not, some of these components might or might not exist, for example, mobile assessment. Mobile communication technology, when applied to the learning environment can enable access to lecture notes, slides or recordings; access to reference material and other learning resources, collaborative learning, easy participation and attendance monitoring, communication with instructors, access to special information such as clinical records and so forth remotely (Bedi & Yucel, 2013). Reflecting on the descriptions of m-health and m-learning, it is easy to see that to some extent, m-health includes m-learning. Figure 2.1 illustrates this relationship

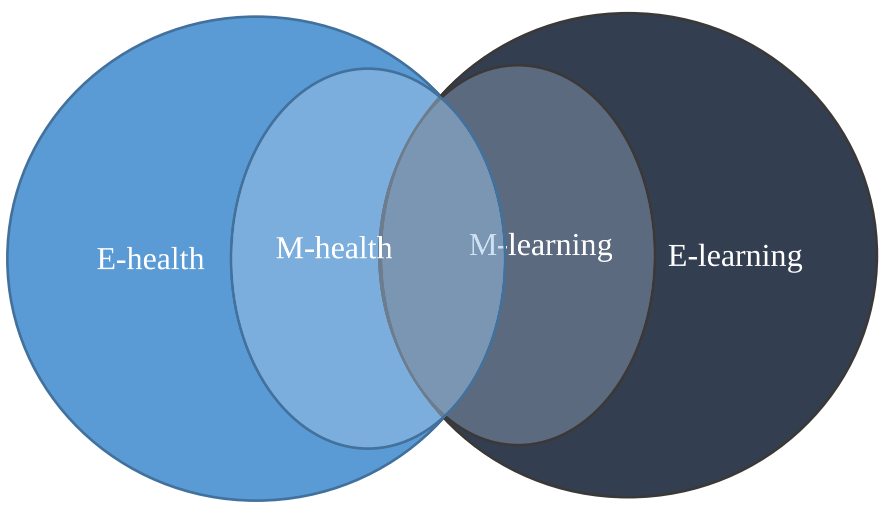

Figure 2.1: Relationship between m-health and m-learning

2.4 Evaluation and impact of m-health

M-health technologies have been evaluated using different research designs, many of which are randomized controlled trials (RCTs) (Carter, Burley, Nykjaer, & Cade, 2013; Free et al., 2013; Hamine et al., 2015; Turner-McGrievy et al., 2013). Although RCTs are of great use in quantifying the impact of interventions, whether on patients or health systems, other research designs may help understand why so much or so little impact is observed. Mixed methods designs have also been used in evaluating m-health interventions. Chang et al. (2011) assessed the impact of m-health technology for peer health workers on AIDS care in rural Uganda. Vodopivec-Jamsek, de Jongh, Gurol-Urganci, Atun, and Car (2012) reviewed studies involving quasi-randomised controlled trials (QRCTs), controlled before-after (CBA) studies, and interrupted time series (ITS) studies with at least three time points before and after the intervention. Engebretsen (2005) also used mixed methods to examine factors influencing the intention to use and accept EpiHandy.

There are thousands of m-health apps out there developed by individuals, non-profits and commercial entities, whose evaluations have not been published anywhere—neither in academic nor grey literature. There is a tendency to rely on number of downloads/users as a measure of success for m-health technologies targeted at the public (Fildes, 2008; FreedomHIV-AIDS.in, 2008). Although download statistics might give an indication of how popular and perhaps how beneficial these apps are to users, they do not give the full picture. The design of an app's icon may simply be too attractive to ignore, therefore people might download it only to uninstall it shortly after it, if it does not meet their expectations. On the other hand, an app designed to be used as part of a health professional's work is not likely to have millions of downloads as with apps designed for the public and promoted through social media. Therefore, download statistics alone give little information about the benefits of a m-health app. It is therefore important to find out actual usage among various target populations by going into those populations.

Evaluation of m-health refers to studies that have been conducted prior to, during or after their full-scale implementation. The studies being referred to here would in no way be limited to the technologies—m-health products—alone, but would include the projects, programs and organizations through/in which they are implemented. This is important because as Kaplan & Harris-Salamone (2009) note, sociological, cultural and financial factors are increasingly being implicated as causes of failure of many health IT projects. A good proportion of the studies that eventually get published end up in grey literature because many of them are more business, government or aid agency driven than academic (Malvey & Slovensky, 2014).

Given that m-health technologies are primarily aimed at helping to improve people's health and health service delivery, it is important that these outcomes be assessed in evaluation studies. Measuring m-health impact on health outcomes is not common in the literature, compared to the vast array of publications on m-health in general. This lack of studies on the impact of m-health on health outcomes is partly because many m-health technologies form only a piece of larger health programs and so it becomes difficult to ascribe health-related outcomes to m-health technologies alone (Mechael, 2009). Furthermore, many of the studies have been conducted over such short periods of time and involving so small numbers of users that it is difficult to measure health-related outcomes, except for some infectious diseases. Studies that have been conducted so far include a randomized-controlled trial comparing the effect of self-monitoring either using mobile apps or not on weight loss and physical activity (Turner-McGrievy et al., 2013). Another study by Knight et al., (2014) found m-health technology combined with physical activity prescription to be useful for health promotion by demonstrating significant differences in participant vital signs, monitored remotely by m-health technologies. A study by Kristjánsdóttir et al., (2013) involving women with chronic widespread pain showed that a m-health patient diary and feedback tool reduced patient anxiety and prevented increases in functional impairment and symptom levels. Furthermore, a randomized-controlled trial found a mobile phone intervention to improve adherence to antiretroviral treatment in a resource-limited setting (Pop-Eleches et al., 2011). In addition, a study involving the use of tablet computers with videos and three-dimensional images to provide information to patients, evaluated patients' understanding of their conditions and discharge procedures, and their perceptions of their attending health resident physicians (Schooley, San Nicolas-Rocca, & Burkhard, 2015). Patients found the system to be positively facilitating their understanding of medical information, while facilitating communication between them and their physicians.

Although the studies cited above appear to show m-health interventions as being beneficial, some studies have reported mixed results (Hamine et al., 2015). Furthermore, Chomutare, Fernandez-Luque, Årsand, and Hartvigsen (2011) found that functionalities provided in many diabetes m-health apps did not properly match evidence-based guidelines for the self-management of diabetes in the United Kingdom. Similarly, Brahmbhatt et al. (2017) found that none of the 201 diabetes apps they reviewed satisfied all 15 criteria they had identified as being necessary for the management of diabetes. Another study found that there was no difference in adherence to evidence-based guidelines between free and paid-for apps (Pagoto, Schneider, Jojic, DeBiasse, & Mann, 2013). A scoping review by Fiore (2017) reveals that there are “limited resources available to evaluate health and medical mobile applications” (p. 113). These findings illustrate a need for some form of screening or rating system to ensure that users, including health care professionals, can easily find user-friendly, evidence-based m-health technology with proven positive impact.

M-health technologies have been evaluated using various methodologies and criteria, and this makes it difficult for users to compare apps and other technologies quickly and objectively. Many attempts at addressing this problem have involved the use of existing criteria for assessing health information on the internet such as the Health on the Net Foundation Code of Conduct (HONcode) (Fiore, 2017). This lays out eight principles on which to judge health-related information, namely, authoritative, complementary, privacy, attribution, justifiability, transparency, financial disclosure, and advertising policy (p. 110). Similarly, the United States Agency for Research and Quality (AHRQ) has developed seven criteria to evaluate internet health information which can be applied to m-health. These are credibility, content, disclosure, links, design, interactivity, and caveats (p. 110). Other criteria that have been developed include RADAR, which stands for relevance, authority, date, appearance and reason for writing and CRAAP-O, which stands for currency, relevance, authority, accuracy, purpose and O for how easy, fun or interesting it is to use (p. 111).

Golden and Krauskopf (2016) developed a set of criteria specifically for evaluating mobile apps. These criteria, presented in the form of a mnemonic (NPMEDAPP), are outlined in the table below.

Table 2.1: NPMEDAPP mnemonic for evaluating mobile health apps (Golden & Krauskopf, 2016, p. e27)

Criterion	Description
Novel	Assesses how innovative the app is, whether or not the information/services being provided are already being provided by other apps, and if it is the best solution to the user's needs
Potential	Assesses the potential benefit the app provides against any potential risks
Medically sound	Assesses how accurate, reliable and up-to-date the medical information provided is
Ease of use	Assesses the user-friendliness of the app
Developer	Assesses who developed the app and the credibility associated with the developer. Credibility is important not only for assuring reliability of information provided, but also for assuring privacy and confidentiality are protected.
Audience	Assesses the user group for whom the app was developed such as clinicians, patients or carers.
Price	Assesses whether or not there are costs associated with installing the app, or add-on features and services.
Platform	Assesses if the app is available on multiple operating systems since this has implications for exchange of information between and among care teams, patients and carers.

In order to provide a more universal, reliable and validated scale for assessing app quality, the Mobile App Rating System (MARS) was developed (Stoyanov et al., 2015). Its development involved scanning literature for publications involving quality assessment of mobile apps. The 25 articles obtained from this search yielded 372 criteria, after duplicates were eliminated. These criteria were organized into 5 categories, namely engagement, functionality, aesthetics, information quality and quality scale (subjective), with a total of 23 items for measuring them. It also includes an extra section for assessing "the perceived impact of the app on the user's knowledge, attitudes, intentions to change as well as the likelihood of actual change in the target health behaviour" (Hides et al., 2014, p. 26). Each item was measured on a five-point scale, and mean scores per category were totalled to give an overall score for the app. The resulting scale was validated using 60 randomly selected apps from the iTunes App Store and showed high levels of internal consistency and interrater reliability (p. 5). The authors recommended that before rating apps, users should use apps for at least 10 minutes during which they should try all features and buttons. They have also published a 20-item version of MARS for users who are not professionally trained raters (p. 28).

One challenge associated with using evaluation mnemonics and scales such as those described above is that they require users to spend some time engaging with apps in order to determine which one(s) are problem-free and suit their needs. Indeed, for anyone who wants to use an app for anything as important as his/her health, it is best to spend as much time as possible to conduct a thorough assessment of any app before deciding to use it. However, considering the thousands of apps out there, this can be a daunting task. Having a credible collection of apps rated by health professionals and patients can give new users a head-start in this process. iMedicalApps is a website where physicians, allied health professionals, medical trainees and m-health researchers provide reviews and research on medical and health apps they have used (iMedicalApps, 2017). Ranked

Health is website that performs similar functions, identifying both the best and worst apps on the app market. It is a project that started in 2016 and is run by the MIT Hacking Medicine, a non-profit organization run by the Massachusetts Institute of Technology (MIT Hacking Medicine, n.d.)

Studies looking at the impact of m-health at the organisational level measured outcomes such as effect on work motivation, data entry time, data entry errors, ability to do away completely with paper records, efficiency of diagnosis and treatment, and use in real-time field data collection (Anantraman et al., 2002; Cisco Internet Business Solutions Group, 2006; Community Health Information Tracking System [CHITS], n.d.; Curioso et al., 2005; Klungsøyr, 2004; Marcelo, 2009; Premji, Casebeer, & Scott, 2012; Schuster & Brito, 2011). While some studies only reported perceived cost savings, others succeeded in quantifying these savings by conducting proper cost-comparison analyses (Krishnan, Nongkynrih, Yadav, Singh, & Gupta, 2010; Schuster & Brito, 2011). Cost savings were reported to be associated with providing medical advice and monitoring treatment compliance remotely and reducing the financial burden of having low-income patients commute to health facilities.

One key thing to bear in mind when looking at publications involving m-health, as with other information systems, is the likelihood of positive bias in publication of results. Researchers are more likely to publish positive findings and not failings. Many studies take on a deterministic approach and focus on a few narrowly defined set of outcomes for evaluation (Chib, Velthoven, Car, Chib, & Helena, 2015; Nasi, Cucciniello, & Guerrazzi, 2015; Peiris, Praveen, Johnson, & Mogulluru, 2014). Furthermore, there have been others that did not go beyond the pilot stage (Shuchman, 2014).

M-health could be very useful for research purposes. One way in which m-health could facilitate research is data collection. Considering that the categories (see Table 1.1) with the largest number of m-health PPPs found in this review of the literature were of the data collection type presupposes that there will potentially be a lot of health-related data for research out there in the possession of health institutions, research groups, commercial entities, and the like. Some m-health are developed specifically for research data collection, others inevitably collect data in order to be able to perform their stated functions, while others do both.

One example of m-health developed specifically for research data collection is EpiCollect (Aanensen, Huntley, Feil, al-Own, & Spratt, 2009; Aanensen, Huntley, Menegazzo, Powell, & Spratt, 2014). This is a web-based application for epidemiological data collection. It is built on the Android platform and provides GPS tagging of data that are collected. It was developed by researchers at Imperial College London and sponsored by the Wellcome Trust. It has been used in Mali, Burkina Faso, Tanzania, Zambia and Zimbabwe.

An example of m-health that collects data although not specifically developed for research is the Mobile Technology for Community Health (MoTeCH) initiative. It was a pilot project led by the Ghana Health Service (GHS) in partnership with the Columbia University Mailman School of Public Health Heilbrunn Department of Population and

Family Health, the Grameen Foundation, and the Navrongo Health Research Centre of the Ghana Health Service and funded by the Bill & Melinda Gates foundation. The initiative, which sought to improve efficiency in management of health information among small community-based nurses, was piloted between May 2010 and February 2012 (Awoonor-Williams, 2013; Ghana Health Service, 2012). It employed mobile phones as a means of capturing patient data using OpenMRS at the backend for managing patient records. The system also served as a means of giving evidence-based health information to the community-based nurses, pregnant women and new parents, while at the same time sending personalized alerts/reminders to pregnant women and new parents to help improve health outcomes (Awoonor-Williams, 2013; Ghana Health Service, 2012).

An example of m-health that collects data both for research and practice is mCare based in India (Centre for Development of Advanced Computing [C-DAC], 2015). According to C-DAC, "mCare uses mobile devices to provide a health management system that could enhance the quality of health care provided by the health workers. The product has two major components: Handheld device-based data collection module and web-based health management information infrastructure module. The system maintains a centralized demographic and public health data, which can be used for analytics" (C-DAC, 2015, para. 5).

2.5 m-health in medical education

Use of mobile technology for educational purposes seemed to have shot up around the turn of the millennium, with the increasing number of conferences organized in this field (Traxler, 2005). Over the nearly two decades in which mobile technologies have been in use in teaching and learning, technology, contexts and attitudes have evolved. In reviewing the literature for this study, the following would be important issues worth focusing on (1) the types of m-health used and the contexts within which they were used, (2) affordances or benefits of m-health use, and (3) constraints, challenges or drawbacks of m-health use.

When it comes to how m-health is used in medical education, two possibilities come up. First of all, mobile computing devices may be used to aid teaching and learning, as with any other subject or course outside medicine. Secondly, since medical training also includes hands-on clinical instruction, m-health may also be used directly or indirectly in-patient care.

Mobile computing/communication devices such as smartphones, tablets and laptops are already being widely used by university and college students, and medical/dental students are no exception. The reasons for such wide use seem obvious. If not for any reason at all, these devices offer quick and easy access to information from almost anywhere. When it comes to training of health professionals, there is an increasing number of apps and peripheral add-on devices or wearables that extend the capabilities of smartphones and tablets. Some of these add-ons perform the same functions as traditional medical devices such as stethoscopes, ultrasound probes, electrocardiography (ECG) and electroencephalography (EEG) monitors, otoscopes, and pulse oximeters, and some of these have been approved by the US Food and Drug Administration (FDA) (Lippman, 2013). Some of the apps and add-ons might be cheaper for students and medical schools to buy than traditional devices (Gaglani & Topol, 2014).

The types of m-health devices used in schools have evolved with time as technology evolves. While some schools provide these devices for students, others require students to purchase them as part of their learning materials (Ellaway et al., 2014; Jackson et al., 2005; Maguire & Clayman, 2010; Mathis, 2011; Stanford University School of Medicine, n.d.).

In 2003, Wayne State University School of Medicine, Detroit MI, implemented a program to incorporate handheld computing devices or pocket PCs (PPCs) into their four-year undergraduate medical program (Jackson et al., 2005). It involved providing minimum technical specifications for devices for students in their second and third years to purchase devices of their choice. Toshiba PocketPC e740, e750 and e755, and Dell Axim were the most popular devices based on available features for price (p. 2). In 2004, the program was expanded to include all students in the school and Toshiba PocketPC e800 was specified as the required device because the Toshiba devices purchased by students in the previous year had much less frequent breakdowns. Students were given orientation regarding the program and provided applications required for their respective years of study. Faculty members and support staff were also trained separately in consonance with their roles. Functions included student attendance tracking, course evaluation, course material provision, interactive learning, clinical note taking and clinical decision support (pp. 3-6). Among the affordances reported during the study were that conducting course evaluations and grading clinical notes taken by students became less labour and time intensive (p. 8). There was better interactivity in class (class size was about 260) and students found clinical decision support systems to be very helpful. A student survey on the PocketPC program showed that majority of them found the program "extremely useful" (p. 7). There was also feedback regarding constraints, some of which were addressed during the study period, while plans were outlined to address others in subsequent years. Students disliked the need to sign on to the wireless network from time to time, and this was resolved when the school implemented an authentication server. With that, students did not have to sign into the wireless network regularly (p. 7).

In 2007, the Northern Ontario School of Medicine (NOSM) began a program of providing handheld computing devices to its undergraduate students in the first and third years (Ellaway et al., 2014). This program was modified in 2010 whereby new medical students were provided a laptop computer and an iPad each, for learning purposes. Students entering their third years of study were given a replacement laptop computer and a choice between an iPhone or iPod Touch each. All students were provided with the Lexi-Complete app suite (Lexicomp, Macedonia, OH; now owned by Wolters Kluver N.V., Alphen aan den Rijn, Netherlands). The curriculum was not changed to make any special provision for the devices; faculty members were not expected to make any accommodation for the devices in their teaching, and neither were they given any special training or support in that regard. Two years into the modified program, researchers investigated how students were using the devices in the context of their learning environment, factors influencing their use and what benefits, or disadvantages students experienced with the use of those devices. Key among findings were that mobile device use depended on functions available and user need in a specific situation. They found that the iPhones, iPads and iPods did not replace laptop computers but rather complemented them (Ellaway et al., 2014). Many students in the upper years reported challenges while using the mobile devices in the presence of their instructors. Some instructors probably assumed students were doing things other than learning when they brought out their smartphones or tablets and communicated this either verbally or in writing to students. Although some students continued using their devices despite these warnings, others simply stopped using them (p. 135). Instructors hold an enormous amount of social power over their students, and this may be greater than the social influence that students may have towards each other.

Telementoring is a field that is growing in interest as far as m-health is concerned. A telementoring robot (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) in conjunction with a laptop computer was used by two surgeons experienced in minimally invasive pediatric surgery in the United States, to mentor two surgeons in France (Bruns et al., 2016). The study found that the telementoring robot/laptop computer setup was an effective means of transferring knowledge while overcoming geographic barriers. Furthermore, having a prior relationship between mentors and mentees greatly improved knowledge transfer. The operating surgeon had initial challenges hearing the mentor speaking due to the amount of noise in the operating theatre. This was addressed by providing the surgeon with a headset in the second case (p. 78).

In a single-blind study conducted at Harvard University, 34 surgeons were asked to assess two videos of a surgical procedure, captured using two devices: Google Glass prototype (Google, Mountain View, CA) and Apple iPhone 5 (Apple Inc., Cupertino, CA) (Hashimoto, Phitayakorn, Fernandez-del Castillo, & Meireles, 2016). Google Glass is a pair of spectacles equipped with a camera capable of storing and transmitting video and images wirelessly to other devices (Google Developers, n.d.). Video from the Google Glass was transmitted to an in-house attending surgeon via the Google Hangouts application while that captured by the iPhone was transmitted live using the Facetime application. The two recordings were done simultaneously by a senior resident and a second attending surgeon as the surgical procedure was conducted by a junior resident. The two recording devices were positioned in such a way that they would capture the view from the junior resident's eye level.

Over 80% of surgeons assessing the post-operative videos from the Harvard University study reported that the video from Google Glass was poor and inappropriate for telementoring, while 26.5% of them felt the same for iPhone 5 (Hashimoto et al., 2016). Beyond just video quality, several practical issues were identified that in my opinion, would make using any of the devices difficult. Although Google Glass allows for hands-free recording and viewing (because it is a wearable technology and voice command operated), its camera resolution was found to be low and the camera's viewing angle could not adjust to match the natural human line of sight when performing near vision tasks (p. 377). Apple iPhone 5, on the other hand had better video resolution, although it needed to be held by another person. Mounting it on the operating surgeon to obtain his line of sight is possible, although this would take away the opportunity to see the mentor and have a face-to-face interaction (p. 377). Although public sale of Google Glass has been discontinued (BBC, 2015) the product is still in development and Google seems to be targeting other technology companies to develop third party uses for the product. Among companies listed on the Glass for Work website are those working on health applications for the product in areas such as surgery, telemedicine and electronic health records (Google Developers, 2016). Surgery is a specialty that requires accurate visuospatial coordination therefore any technology that limits this is not likely to be received well. Effects on practitioner-patient interaction needs to be studied.

The use of videos and social media to mentor colleagues in the field of surgery was described by Ibrahim, Varban, and Dimick (2016). Increasingly, major surgical equipment such as those used for endoscopy, laparoscopy and thoracoscopy are being equipped with video recording capabilities, and surgeons have begun sharing videos of procedures on social media platforms such as a 1900-member strong Facebook forum called *International Hernia Collaboration* (p. 240). Here, members share best practices and get feedback and questions regarding their procedures from colleagues. The videos are used in pre-operative preparations by surgeons who do not have much experience in handling similar cases. Some operations are streamed live, and this serves two purposes. First, surgeons use these sessions to continue mentoring their students who may have returned to their home institutions. Second, experienced surgeons performing operations obtain assistance in modifying their techniques (p. 241). Although no mention of m-health was made in the article, the second figure in the article showed a surgeon watching a live video feed on a laptop computer, while another surgeon reviews a post-operative video with a peer expert on a laptop computer (p. 241). Laptop computers, as per the definition of m-health provided in the Chapter 1 qualifies as m-health because it is being used for communicating information (live video stream) for the purposes of health care. Furthermore, studies show that most people interact on social media using mobile devices, as compared to desktop computers (Lenhart, Purcell, Smith, & Zickuhr, 2010).

Medical students, physicians, patients and carers in a paediatric and an adult hospital in Australia were studied to determine how they used mobile devices for work and health-related purposes (Scott, Nerminathan, Alexander, Phelps, & Harrison, 2017). It was a mixed-methods design involving separate survey questionnaires for students and physicians on one hand, and patient and carers on the other. This was followed by focus group discussions to obtain more in-depth information. The study found that about 90% of students and physicians owned a smartphone, while around 30% of them owned a laptop or tablet computer (p. 182). Proportions of students and physicians who communicated via emails and text messages for medicine-related activities were similar, averaging around 62% (p. 182). However, significantly more students used mobile devices for learning, compared to physicians (p. 182). This is not surprising considering that the primary occupation of students is to acquire all the necessary knowledge and skills, in order to become full practicing physicians. Interestingly, significantly more students used their mobile devices for purposes that were unrelated to medicine and for social media, compared to physicians (p. 182). More students reported accessing drug and treatment information and confirming information they already knew as their best affordances compared to physicians, while more physicians reported accessing their calendars and to-do lists as their best affordances (p. 183). The worst constraints for students were being unsure of the attitudes of instructors, patients and carers. Both students and physicians were constrained by having problems with internet access and other technical difficulties. Despite these constraints, only a small proportion of students and physicians (about 9%) reported mobile devices as being difficult to use (p. 183)

Ponce, Mendez, and Penalvo (2014) conducted a study to investigate how medical students and professionals (consisting of residents, instructors and specialists) at the University of Salamanca Medical School in Spain used mobile devices for educational purposes, and what roles each group played in this process. About 94% of respondents owned a smartphone and/or tablet computer (p. 306). Students spent about twice as much time (median: three to four hours per day) using their smartphones compared to medical professionals. In contrary to the study by Scott et al (2017), more medical professionals used medical and medical education applications than students, and this was attributed to lack of knowledge about availability of such applications or a need to use them (p. 309). This finding illustrates that contextual differences play an important role in determining m-health use among medical students and professionals.

Portable digital assistants (PDAs) were provided to 387 students in years three to five of the five-year integrated undergraduate medical program at Brighton and Sussex Medical School in the United Kingdom (Davies et al., 2012). The mobile devices had various resources pre-loaded onto them such as the British National Formulary (BNF), Cochrane Abstracts (COAB), Evidence Based Medicine (EBM) Guidelines (EBMG), Oxford Concise Medical Dictionary (OCMD) and Oxford Handbook of Clinical Medicine (OHCM). Pre- and post-use surveys and usage tracking data provided descriptive quantitative data about usage, while focus group discussions (FGDs) were used to explore how they used the devices and other experiences. The main perceived pre-use affordances reported by students were accessing information instantly and easily carrying the device around. The main perceived pre-use constraints were losing the devices, depending too much on the technology and appearing disrespectful to others (pp. 3-4). Less than half (47%) of those that completed the post-use survey used the mobile devices at least once a week, while about a quarter of respondents (24%) had not used their devices at all, citing having to carry multiple devices, having other learning preferences and having concerns about losing the devices as the main constraints (p. 4). It was not stated whether there was any relationship between those who did not respond to the survey and usage frequency. Among those who used the devices, accessing information in a timely fashion (mainly the BNF and OHCM) were among the greatest affordances (p. 4). They also reported maximizing their time by using their devices for learning in periods of time which would have otherwise been wasted (p. 4). In stark contrast to the frequency of use data, 98% of respondents felt that the program should be continued (p. 4). Attitudes of patients, teachers and others to the PDA use was largely mixed, with similar numbers reporting positive, negative and neutral feedbacks (p. 5).

Through a collaborative venture captioned Botswana-University of Pennsylvania Partnership (BUP), four m-health projects (telemedicine) were piloted in Botswana involving 24 clinicians and 33 medical students between 2010 and 2012 (Littman-Quinn, Mibenge, Antwi, Chandra, & Kovarik, 2013). The clinicians came from four specialties—women's health, radiology, medicine and dermatology—in 11 health facilities across the country. The medical students were from the University of Botswana School of Medicine, and Orange Botswana was the telecommunications partner. The projects involved providing smartphones running the Android operating system to health workers in various facilities, clinicians and medical students. The devices contained selected medical information apps such as Dynamed, Archimedes, Medscape, ePocrates Rx and 5-Minute Clinical Consult (p. 121). In 2012, 7-inch tablet computers were introduced to replace some of the smartphones, and the project was set to expand with the addition of 151 new medical students, residents and their tutors. Using these devices, the health workers would document (including images) cases and consult an in-country specialist (one per specialty) for diagnoses and interventions. The in-country specialist could also consult an international specialist for a second opinion. A total of 643 cases were managed using the system during the piloting period. Key benefits included improving access to specialist care for patients, improving communication between on-site clinicians and remote specialists, improving collaboration among clinicians and medical students, empowering clinicians and reducing referrals, thereby minimizing costs for patients and the healthcare system (Littman-Quinn et al., 2013). There were many barriers, and these were grouped into technical and social, each of which was then broken into internal and external. The major internal technical barriers included insufficient support, server hacking attempts and device malfunctions (e.g. SIM card failure, phone battery exhaustion and internet disruptions). External technical barriers included power outages and malfunctioning radiology equipment, which meant patients could not be attended to in that facility for about a year. The major internal social barriers included device misplacement, theft and damage though spillages. Use was also constrained by participants having unfavourable perceptions about m-health and its effects on workflow. The major external social barriers included a public-sector strike in which study participants were involved. Use was also constrained by having a high staff turnover rate (p. 122). Interventions were put in place to address some of the challenges during the pilot, while plans were clearly outlined to address the remaining ones during the scale-up phase. Among these were provision of protective cases for devices, installation of power-saving and tracking apps, close collaboration with the telecommunications partner, and using peer-trainers for participants (p. 122).

In Japan, a group of researchers were interested in helping medical students to improve their English language and English medical terminology skills by using mobile technology (Iwata, Telloyan, & Murphy, 2016). Based on a needs assessment survey that showed 60% of students already used mobile devices for studying English, they devised an e-learning system whereby they sent messages to 242 subscribers twice a week. Each message contained an English phrase for students to learn and a link to 5 multiple-choice quizzes (p. 152). A survey (49.6% response rate) conducted a few months later revealed that 45% of respondents found the content to be effective or very effective. Furthermore, 60.8% found delivering two messages per week was appropriate. Despite these findings, the rate of quiz participation averaged 9.5% (p. 154). Based on comments from this survey, the program was modified to have shorter messages, and new subscribers (209 students) were given positive feedback from previous subscribers in order to motivate them. The second survey (30.6% response rate) showed that the rate of quiz participation averaged 24.3% (p. 155). Furthermore, over 90% of respondents found the content to be effective or very effective, while 82.8% were pleased with the frequency of messaging (p. 156).

A mobile app was developed on the Apple (iOS) and Android operating systems to facilitate continuing medical education (CME) courses (Wittich et al., 2016). This app, which was free to download, could be used before, during and after an on-site CME course. Participants attending the 26th Annual Selected Topics in Internal Medicine Course were informed about the app through pre-course emails and at various points during the course (p. 70). The app had the following features among others: "ability to download all presentation slides, take notes, and add highlights; search functions; social networking and texting with other attendees; and access to presenter information, including email addresses" (p. 70). A survey conducted at the end of the CME course had an 82.7% response rate (498 respondents; 466 analyzed) and showed 62.9% of course attendees used the app. Younger physicians and those with previous familiarity with apps formed the majority of users. More females had a positive attitude towards the app than males (p. 72). The survey included seven statements that assessed app educational value and three that assessed its usability and appeal, on a five-point scale. Seven out of these statements were framed as affordances, and to these, participants tended to agree, according to mean scores obtained. The affordances were as follows: improving participant learning; staying more engaged; gaining more knowledge; applying what has been learned; enhancing participant education; using app easily; and using it intuitively (p. 71).

Tran et al. (2014) reported experiences and attitudes of medical students at the University of Toronto towards using personal mobile technology in the clinical setting. Their study focused on patient confidentiality and student professionalism. The researchers reported that 98% of respondents owned a smartphone, and 86% of respondents used them for communication involving patient-related information with colleagues. Furthermore, a large majority of the students reported that using the smartphone made clinical work more efficient (94%) and enabled provision of better care (86%). Majority of the students (68%) admitted that there were risks associated with exchanging patient-related information, 26% of them did not have any security features on their phones.

Payne et al. (2012) conducted a survey to assess smartphone acceptance and patterns of app use among 257 medical students and 131 foundation level junior doctors in the United Kingdom. They found that about 79% of medical students and about 75% of junior doctors surveyed owned a smartphone with more than half of each group owning an iPhone. Majority of respondents had between one and five apps on their smartphones. Junior doctors used disease diagnosis/management and drug reference apps the most, while medical students used timetable, objectives for lectures/modules and logbook apps the most. This clearly reflects the differing needs of the two groups.

Free Open Access ‘Med(ical Ed)ucation’ (FOAM) is a collection of medical education resources being provided in free and open access form via the web to a community of users (C. P. Nickson & Cadogan, 2014). Social media has been instrumental in the growth of its community of supporters, and the spread of its resources. The name FOAM was coined in 2012, although the community has been in existence for quite a while before this. Although there have been calls to have FOAM resources organized like a journal, with peer review, its key advocates insist that “FOAM is not scientific research. Instead, FOAM is a useful way of disseminating, discussing, dissecting and deliberating over the products of that research – as well as exploring issues where research findings do not apply, or simply do not exist” (p. 77). The authors admit that some of FOAM materials cannot be considered anything more than opinions (p. 77). With respect to medical education, the authors point out that FOAM is there to complement textbooks and not to replace the medical education curriculum (p. 80). Indeed, the nature and organization of information will make it difficult to be solely relied upon for medical education. Importantly, the very nature of these resources makes them suitable for self-directed learning (p. 80). FOAM resources are available on over 240 blogs and podcasts (p. 77) which are searchable through the GoogleFOAM portal (“Google FOAM,” n.d.; C. P. Nickson & Cadogan, 2014, p. 81). Resources are currently available in nine languages, namely Czech, Dutch, English, Italian, Mongolian, Polish, Russian, Spanish and Turkish (C. Nickson, 2017).

MEDSKL.com is a website that provides courses and other materials for medical students, physicians and medical tutors to “learn and review the fundamentals of clinical medicine” (Medskl, n.d., para. 1). According to the website, resources are developed by about 200 top medical school professors around the world, with each module undergoing peer-review. The website is a member of the FOAM movement and hence its resources are available for free. These are resources that medical students could access using web browsers and social media apps on their mobile devices. It would be interesting to investigate as part of this study, whether medical students in Ghana are aware of and using these resources alongside OER resources (see section 1.3).

It is common knowledge that social media is widely used by university students, and medical students would be no exception to this. In a systematic review and meta analysis of medical students’ use of social media for educational purposes, Guraya (2016) found that 75% of students surveyed used social media, while 20% used it for sharing educational information. This, however, does not capture those that use social media for information seeking purposes.

Bahner et al. (2012) developed an ultrasound curriculum tailored for the social media platform Twitter, which at the time allowed messages of up to 140 characters to be sent at a time. On November 7, 2017 Twitter increased the character limit of tweets to 280 characters. The curriculum was also used on Facebook. One module was delivered per month using one daily tweet, for a period of one academic year. At the end of the study period, a survey link was posted on Twitter, Facebook and email to assess the impact of the program. Users following the social media accounts comprised physicians, students, corporate affiliations and ultrasound technicians (p. 3). The Twitter feed had more followers than Facebook, and among those that completed the survey, medical students (29.4%) were significantly less likely to use Twitter than non-students prior to the ultrasound program (p. 4). This study illustrates that medical students and health professionals use social media for self-directed learning, and do not necessarily have to already be using a social media platform in order to leverage it as a source of educational information.

Indeed, medical schools have begun using social media as part of their communication platforms. Kind et al. (2010) looked into social media use by all accredited US medical schools and investigated whether their student policies included anything regarding social media use. The study found that, each of the 132 accredited schools had a website, with about 96% of them having some sort of presence Facebook page. Furthermore, only about 26% had an official Facebook page, while 71% and 55% had students and alumni group pages respectively. With only about 11% of schools having a Twitter account, Facebook was clearly the preferred social media platform for US medical schools at the time of the study. In addition, although about 97% of the schools had student guidelines or policies online, only 10% had a mention of social media in them. Lastly, the degree to which these policies discussed social media differed among these few schools. As medical schools and student groups are using social media for information sharing, it will be interesting to find out whether and how medical students in Ghana use social media in the educational setting.

In summary, m-health has been shown to provide many benefits such as improving knowledge, work efficiency and access to healthcare, while reducing cost of care. M-health has been used for teaching, assessment, learning, patient care, and formal and informal information sharing by medical schools and students. The main devices used were PDAs, smartphones, tablets, cellular phones, laptops and iPods. There are vast amounts of free educational materials of varying degrees of quality available to medical students on the Internet through websites and social media such as Open Educational Resources Initiative (OER), Free Open Access Meducation (FOAM) and MEDSKL. Students reported benefits and challenges associated with m-health use, and there were mixed attitudes from students & faculty regarding m-health use in the learning and clinical setting. Use was impacted by various barriers and enablers outlined earlier in this chapter. Interestingly, not much academic literature was found regarding the use of m-health in medical schools in the developing world. These findings buttress the need for this study on how medical students use m-health in Ghana.

Chapter 3

3 Theoretical Framework

3.1 Theories about technology adoption, use and impact

There are several views of what constitutes a theory in the literature, and these views vary between fields. This study adopts a broader view that defines theories as “abstract entities that aim to describe, explain, and enhance understanding of the world and, in some cases, to provide predictions of what will happen in the future and to give a basis for intervention and action” (Gregor, 2006, p. 616). Shirley Gregor (2006) categorizes information systems theories into five interrelated types, namely, theories for (1) analyzing, (2) explaining, (3) predicting, (4) explaining and predicting, and (5) design and action (p. 614). According to her, none of the types is better than the other; each type leads to the production of a particular kind of knowledge that is valuable to the collective body of knowledge (p. 632). Furthermore, she stipulates that some theories may fit into more than one category or all categories (p. 614). Table 3.1 gives brief descriptions for each theory type.

Table 3.1: Classification of theories in information systems research (Gregor, 2006, p. 620)

Theory type	Description
Analyzing	A theory that provide a description of an object or phenomenon. Such a theory provides a response to the question "what is?"
Explaining	A theory that describes an object or phenomenon and explain why or how things are the way they are, or when and where things take place.
Predicting	A theory that describes an object or phenomenon as it exists, and what it will become in the future. Such a theory would include testable propositions.
Explaining and Predicting	A theory that combines features of the above two types.
Design and action	A theory that gives direction on how to do something

Although there is a general lack of theory-based research on m-health, quite a number of researchers have applied theories from information systems (IS) and other fields in the study of m-health. Theories (including frameworks and models) underlying some of these studies include Action Research Paradigm (Lungo et al., 2007); Health IT Usability Evaluation Model (Health-ITUEM) (Brown, Yen, Rojas, & Schnall, 2013); Fit between Individuals, Task, and Technology framework (FITT) (Sheehan, Lee, Rodriguez, Tiase, & Schnall, 2012); and Gaming Theory, Virtual Reality Theory and Communication Competence Theory (Brown-Johnson, Berrean, & Cataldo, 2015).

Several theories, including frameworks and models (Gregor, 2006), have been developed to guide researchers in studying information systems use. While some of these aim at achieving holistic assessment of systems, others focus more on specific aspects of an IS deployment such as user acceptance, resistance, technical or economic issues. The type of theory to be adopted for any study must match with the goals of the study. This study seeks to understand how medical students use m-health for learning and patient care. As such, an appropriate theory would be one that is used for analyzing or explaining. Among the most prominent theories that fit this description, the HOT-fit Framework, CHEATS Framework, DeLone and McLean Information System (IS) Success Model, Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT) are worth considering.

3.1.1 The Human, Organization and Technology-fit (HOT-fit) Framework

Several studies have shown the importance of social (human and organizational) factors on the success or failure of HIS (Ajzen, 1991; Greenhalgh & Stones, 2010; Tatnall & Gilding, 1999; Venkatesh et al., 2003). Similarly, several studies have identified the importance of a fit between social and technical factors in order to facilitate successful implementation of HIS (Ackerman, 2000; Harrison et al., 2007). The Human, Organization and Technology-fit (HOT-fit) framework, based on the Information Systems Success model and Information Technology -Organization fit model, posits that there needs to be a fit between three factors—human, organizational and technological—if a HIS is to be successful (Yusof et al., 2008). As such, eight dimensions are used to describe and explain the impact of a HIS namely, System Quality, Information Quality, Service Quality, System Use, User Satisfaction, Organizational Structure, Organizational Environment and Net Benefits (p. 389). Each dimension is assessed using evaluation metrics, summarized in Table 3.2. Data regarding these evaluation measures can be collected using appropriate research methods such as questionnaires, interviews, observation, and document reviews. The interrelations between these constructs is depicted in Figure 3.1. As to what is meant by fit, the authors put forward that “fit is concerned with the ability of HIS, human (HIS stakeholders and clinical practices) and setting to align with each other” (p. 389). The HOT-fit framework is useful for identifying which aspects of a HIS setup is experiencing problems, so that appropriate actions are taken to address them.

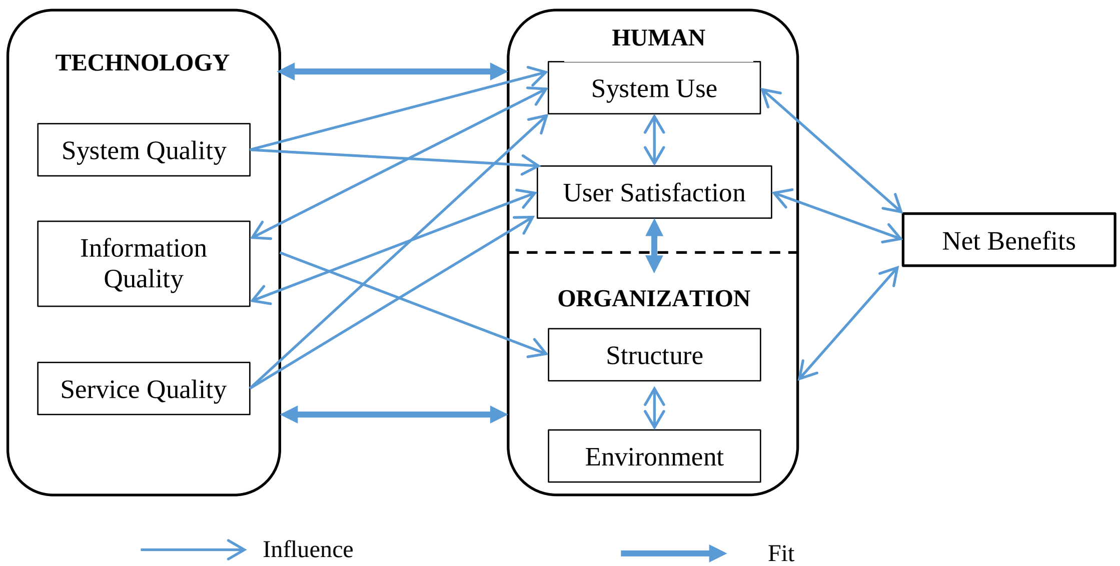

Figure 3.1: Human, organization and technology-fit framework (Yusof et al, 2008, p. 398)

Table 3.2: Human, organization and technology-fit framework evaluation measures (Yusof, Kuljis, Papazafeiropoulou, & Stergioulas, 2008, p. 390)

HOT-fit Construct	**Evaluation Metrics**
[TECHNOLOGY] System quality	Data accuracy, data currency, Database contents, ease of use, ease of learning, availability, usefulness of system features and functions, flexibility, reliability, technical support, security, efficiency, resource utilization, response time, turnaround time
[TECHNOLOGY] Information quality	Importance, relevance, usefulness, legibility, format, accuracy, conciseness, completeness, reliability, timeliness, data entry methods
[TECHNOLOGY] Service quality	Quick responsiveness, assurance, empathy, follow up service, technical support
[HUMAN] System use	inquiries, amount of connect time, number of functions used, number of records accessed, frequency of access, frequency of report requests, number of reports generated), use by whom? (direct vs. chauffeured use,) actual vs. reported use, nature of use (use for intended purpose, appropriate use, type of information used,) purpose of use, level of use (general vs. specific,) recurring use, report acceptance, percentage used, voluntaries of use, motivation to use, attitude, expectations/belief, knowledge/expertise, acceptance, resistance/reluctance, training
[HUMAN] User satisfaction	Satisfaction with specific functions, overall satisfaction, perceived usefulness, enjoyment, software satisfaction, decision making satisfaction
[ORGANIZATIONAL] Structure	Nature, (type, size) culture, planning, strategy, management, clinical process, autonomy, communication, leadership, top management support, medical sponsorship, champion, mediator, teamwork
[ORGANIZATIONAL] Environment	Financing source, government, politics, localization, competition, inter-organizational relationship, population served, external communication
Net Benefits	Clinical practice (Job effects, task performance, productivity, work volume, morale,) efficiency, effectiveness (goal achievement, service), decision making quality (analysis, accuracy, time, confidence, participation), error reduction, communication, clinical outcomes (patient care, morbidity, mortality,) cost

3.1.2 Clinical, Human and organizational, Educational, Administrative, Technical and Social (CHEATS) Framework

The CHEATS framework is built on a need to have an evaluation framework that comprehensively assesses all aspects of a healthcare setup that may be affected by the implementation and use of health information technology (HIT) (Shaw, 2002). The framework puts forward that six items need to be assessed in order to have a complete impact evaluation of any HIT deployment. These items are the Clinical, Human and organizational, Educational, Administrative, Technical and Social aspects of a healthcare setup (p. 210). Table 3.3 outlines measurement variables of each item. The framework employs a mixed-methods approach, informed by a reasoning that the best methods need to be employed to enable researchers to obtain the best answers to research questions. As such, structured, semi-structured and open-ended questionnaires may be used, one-on-one and focus group interviews may be held, research participants may be observed as they carry out their routine activities, and usage data may be collected from health information systems. Findings may be presented as descriptive and inferential statistical summaries, thematic constructs, quotes from interviews, and observational notes.

Table 3.3: CHEATS constructs and their corresponding measurement metrics (Shaw, 2002)

CHEATS Construct	Evaluation metrics
Clinical	1. Quality of Care, 2. Diagnostic reliability, 3. Impact and continuity of care, 4. Acceptance of technology (both by patients and professionals), 5. Changes in work practices and redistribution of resources, 6. Differences in acceptance and efficacy between different areas, 7. Cultural differences, 8. Different patient/client groups, 9. Interviewing techniques, 10. Effects on referral rates, and 11. Appropriateness of referral (pp. 214-215)
Human and Organizational	Interview key people at the interface of different levels of care • Primary–secondary interface, • Secondary–tertiary interface, • Primary–primary interface, • Secondary–secondary interface, • Primary–community interface, • Secondary–community interface (p. 215)
Educational	1. Impact on recruitment and retention of staff 2. Training provision, acceptability and continuity (non-technology specific) (p. 215)
Administrative	1. Convenience 2. Change in interaction styles 3. Cost effectiveness (p. 216)
Technical	1. Appropriateness of technologies implemented, 2. Video and sound quality for the application (if appropriate), 3. Differences associated with different techniques, 4. Ease of use, 5. Technology specific training, 6. Reliability of technology (p. 216-217)
Social	Impact on social contact (p. 218)

3.1.3 DeLone and McLean Information System (IS) Success Model

As its name suggests, the DeLone and McLean Information System (IS) Success Model provides a framework and model for explaining and predicting IS success. It is based on works of several researchers in the areas if IS success, management information systems and communication (Delone & Mclean, 2003). According to this model, success is understood as a multidimensional construct and the original model posits six dimensions and causal relationships between them that come together to give an understanding of how successful an information system is. System Quality and Information Quality predict Use and User Satisfaction with the latter two having an influence on each other. In other words, once people use an IS, they will experience various degrees of satisfaction, which will determine whether they continue to use the system. Use and User Satisfaction in turn lead to Individual Impact, which collectively leads to Organizational Impact. Figure 3.2 illustrates this relationship clearly.

After considering hundreds of studies that used this model and various suggestions for extension, this model was updated whereby Individual and Organizational Impacts were condensed into one dimension—Net Benefit, in close semblance to the HOT-fit framework. Furthermore, an additional dimension—Intention to Use—was added to Use in order to cater for situations where measurement of actual use was not possible. DeLone and McLean were quick to add that intention to use does not invariably lead to actual use, as has been found in many studies such as that of Aggarwal, Kryscynski, Midha, and Singh (2015). Lastly, a new predictor for Intention to Use/Use and User Satisfaction was added—Service Quality—to reflect the importance of IS support to the optimal functioning and use of information systems. Process-wise, IS implementation is broken down into three stages, namely production, use and impact. Figure 3.2 illustrates this relationship clearly.

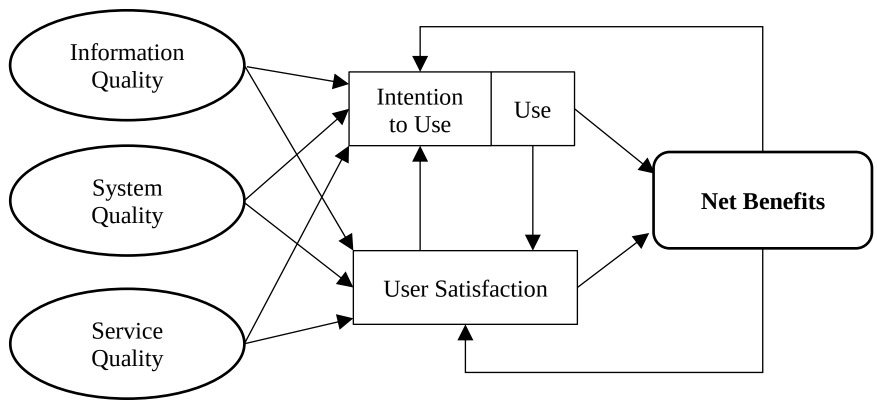

Figure 3.2: DeLone and McLean Information System Success Model (DeLone & McLean, 2003 p. 24)

3.1.4 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) is a theoretical framework used to explain and predict behavioral intention and behavior (Ajzen, 1991). It is based on the notion that behavioral intention (BI) is predicted by subjective norm (SN)—“the perceived social pressure to perform or not perform the behavior of interest” (p. 188), perceived behavioral control (BC)—“the perception of the ease or difficulty of performing the behavior of interest” (p. 188) and attitude towards behavior—“the degree to which a person has favorable or unfavorable evaluation or appraisal of the behavior in question” (p. 188). Actual behavior (B) is in turn predicted by BI and BC. Since evaluation of IS involves assessment of attitudes towards new technology and behaviors such as technology adoption and use, TPB has been quite popular in IS research although it originated in the field of behavioral science. It has its origins in the Theory of Reasoned Action (TRA) and forms the foundation of a number of IS frameworks and models such as the Technology Acceptance Model (TAM) and its extensions, and Unified Theory of Acceptance and Use of Technology (UTAUT). Its popularity may be partly because it has strong empirical validation and strong BI predictive value in non-IS studies (p. 189). Figure 3.3 gives a visual representation of the framework.

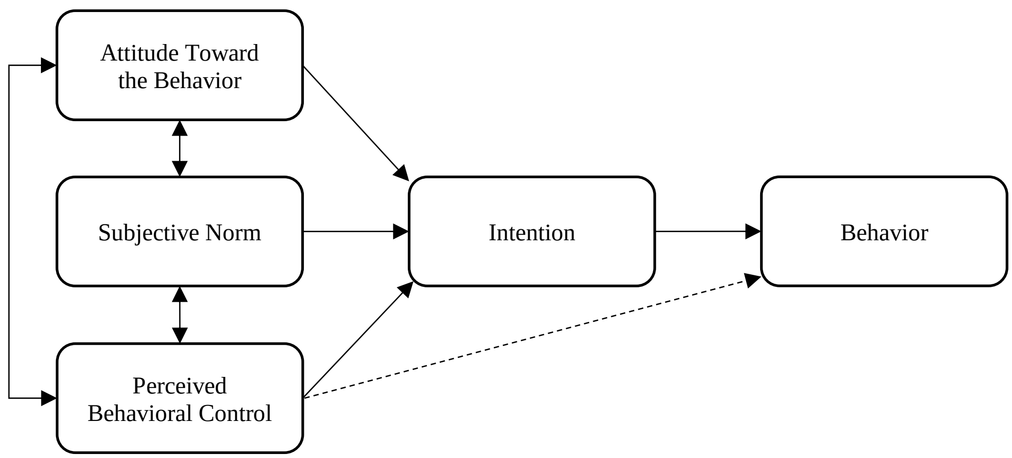

Figure 3.3: Theory of Planned Behavior (TPB) (Ajzen, 1991, p. 182)

3.1.5 Levels of Technology Implementation (LoTi)

The Levels of Technology Implementation (LoTi) framework defines seven levels or stages that characterize the process of technology use in teaching curricula (Moersch, 1995). Importantly, it recognizes that technology adoption and use are processes rather than hard endpoints, and that the instructional style changes from teacher-centered to learner-centered as teachers progress from the first stage—Nonuse (Level 0)—to the last stage—Refinement (Level 6) (p. 41). Typically, as this transition unfolds, there is increasingly less reliance on textbooks and verbal instruction, and more hands-on problem-based learning (p. 41). This framework is useful as a guide in evaluating the progress of technology inclusion into curricula, rather than studying factors that influence technology adoption and use. Table 3.4 gives a description of the stages that make up LoTi.

Table 3.4: Levels of Technology Implementation (LoTi) Framework (Moersch, 1995, p. 42)

Level/Stage	Description
0-Nonuse	A perceived lack of access to technology-based tools or a lack of time to pursue electronic technology implementation. Existing technology is predominately text-based (e.g., ditto sheets, chalkboard, overhead projector).
1-Awareness	The use of computers is generally one step removed from the classroom teacher (e.g., integrated learning system labs, special computer-based pullout programs, computer literacy classes, central word processing labs). Computer-based applications have little or no relevance to the individual teacher's instructional program.
2-Exploration	Technology-based tools serve as a supplement to existing instructional program (e.g., tutorials, educational games, simulations). The electronic technology is employed either as extension activities or as enrichment exercises to the instructional program.
3-Infusion	Technology-based tools, including databases, spreadsheets, graphing packages, probes, calculators, multimedia applications, desktop publishing applications, and telecommunications applications, augment isolated instructional events (e.g., a science-kit experiment using spreadsheets/graphs to analyze results or a telecommunications activity involving data-sharing among schools).
4-Integration	Technology-based tools are integrated in a manner that provides a rich context for students' understanding of the pertinent concepts, themes, and processes. Technology (e.g., multimedia, telecommunications, databases, spreadsheets, word processors) is perceived as a tool to identify and solve authentic problems relating to an overall theme/concept.
5-Expansion	Technology access is extended beyond the classroom. Classroom teachers actively elicit technology applications and networking from business enterprises, governmental agencies (e.g., contacting NASA to establish a link to an orbiting space shuttle via the Internet), research institutions, and universities to expand student experiences directed at problem solving, issues resolution, and student activism surrounding a major theme/concept.
6-Refinement	Technology is perceived as a process, product (e.g., invention, patent, new software design), and tool to help students solve authentic problems related to an identified real-world problem or issue. Technology, in this context, provides a seamless medium for information queries, problem solving, and/or product development. Students have ready access to and a complete understanding of a vast array of technology-based tools.

3.1.6 Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM), famous for explaining and predicting intention to use IS, has featured prominently among IS evaluation models. It accounts for about 10% of IS publications (Lee, Kozar, & Larsen, 2003). The model theorizes that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are predictors of a person's attitude towards an IS, which in turn predicts his/her intention (BI) to use it. Behavioural Intention (BI) predicts Actual Use (AU) (Davis, 1989). Davis defined PU as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320) and PEOU as "the degree to which a person believes that using a particular system would be free of effort" (p. 320). TAM is largely based on the Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB). Figure 3.4 illustrates how key concepts are related. TAM has been shown to be able to explain people's acceptance of IT to a degree of up to 40% (Holden & Karsh, 2010). Arguably, the main reasons why TAM has been so popular are its simplicity, involving the use of very few variables (Bagozzi, 2007) (see Table 3.5). After collecting data using questionnaires, various statistical analyses are conducted to determine convergent and discriminant validity, goodness-of-fit and strength of individual paths in the model. Based on these results, an effect size for BI is obtained, and this is interpreted to predict user acceptance. However, this simplicity is the source of its greatest criticisms—TAM fails to account for other factors that influence user acceptance. Davis rightly admitted from the very outset that "although [PU and PEOU are] certainly not the only variables of interest in explaining user behaviour, they do appear likely to play a central role" (Davis, 1989, p. 323).

In an attempt to account for some of these shortcomings, many researchers included new constructs such as Resistance (see Figure 3.5) (Bhattacherjee & Hikmet, 2007), Personal Innovativeness (PI) and Social Influence (SI) (see Figure 3.6) (Lu et al., 2005). This led to many new TAM versions making it difficult to compare studies.

Table 3.5: Measurement constructs for Perceived Usefulness and Perceived Ease of Use (Davis, 1989)

Perceived Usefulness	Perceived Ease of Use
1. Work more quickly	1. Easy to learn
2. Job performance	2. Controllable
3. Increase productivity	3. Clear & understandable
4. Effectiveness	4. Flexible
5. Makes job easier	5. Easy to become skilful
6. Useful	6. Easy to use

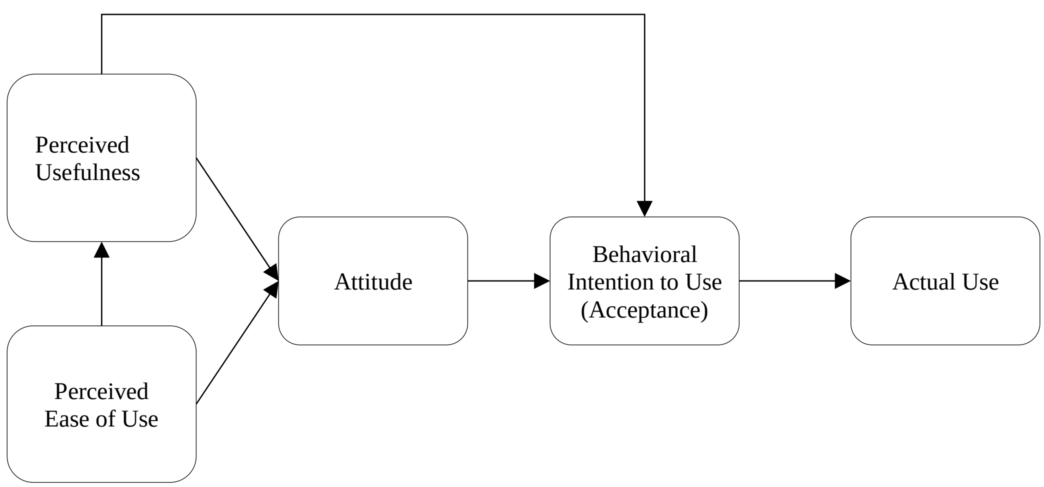

Figure 3.4: Technology Acceptance Model (TAM) (Holden & Karsh, 2010)

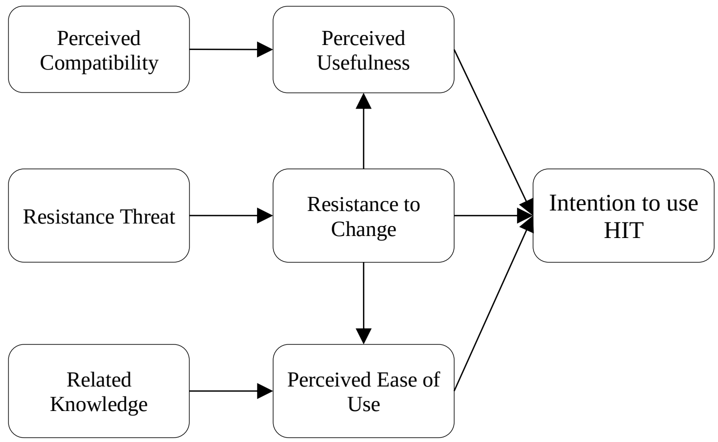

Figure 3.5: Extended Technology Acceptance Model (Bhattacherjee & Hikmet, 2007, p. 728)

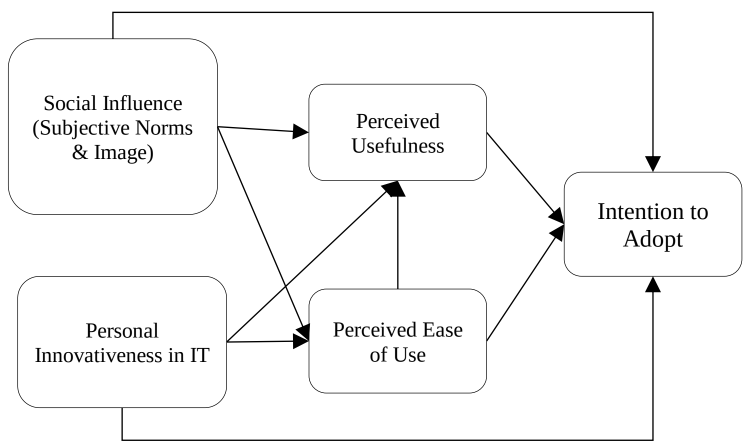

Figure 3.6: Extended Technology Acceptance Model (Lu et al, 2005, p. 254)

Among the notable revisions of TAM is TAM2 which consists of five variables that predict PU (see Figure 3.7). Importantly, this revision brought TAM out of the individual user-centeredness by adding the Subjective Norm (SN), Image (I), and Voluntariness (V), all measures of SI (Venkatesh & Davis, 2000). The newly defined constructs were tested and found to be empirically supported.

Subjective Norm is defined as the perception that significant people in a user's social group expect the user to adopt a technology or not adopt it (Venkatesh & Davis, 2000, p. 187). Voluntariness was introduced as a moderating variable, defined as the extent to which users perceive the decision to adopt a technology to be voluntary (p. 188). Image is defined as the extent to which using a particular technology increases the user's social status (p. 189). TAM2 theorizes that "the subjective norm will positively influence image because if important members of a person's social group at work believe that he or she should perform a behaviour (e.g. using a system), then performing it will tend to elevate his or her standing within the group" (p. 189). Furthermore, it theorizes that "image will have a positive effect on perceived usefulness" (p. 189). It is interesting to note that the authors did not define experience, and understandably so because the amount of effort and time required to attain any defined level of competence will differ from person to person. They however make a very strong case that as one gets more familiar with an IT system, Social Influence pressures reduce (p. 190). It seems that Experience is understood in terms of amount of time spent using a technology. Job Relevance is defined as "an individual's perception regarding the degree to which the target system is applicable to his or her job" and TAM2 theorizes that it will have a positive effect on perceived usefulness (p. 191). Output Quality is defined as "how well the system performs those tasks" and this is theorized to have a positive effect on perceived usefulness (p.191). Result Demonstrability, defined as how real and substantial the results of using the innovation are, is theorized to also have a positive effect on perceived usefulness (p. 192). The newly defined constructs were tested in four longitudinal studies, two involving users whose usage of the IT systems were mandatory, while the other two were voluntary. The constructs in the model were found to be statistically significantly related as theorized except Output Quality, which did not influence perceived usefulness directly, but did so through job relevance.

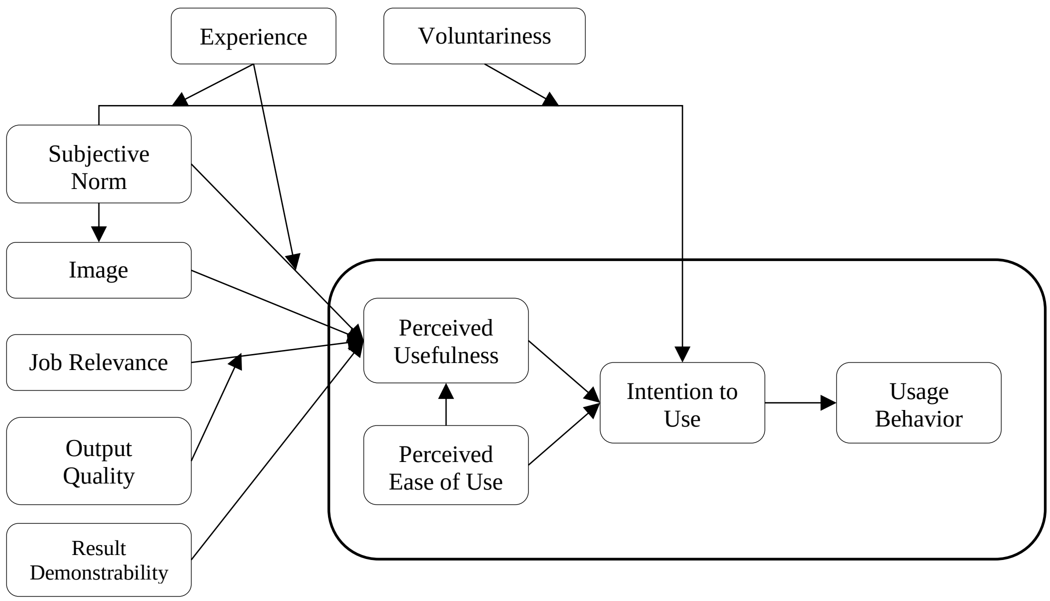

Figure 3.7: Technology Acceptance Model 2 (TAM2) (Venkatesh & Davis, 2000)

3.2 A guiding theoretical framework

Although the theories discussed above are of descriptive and explanatory nature, in line with the objectives of this study, there are a few problems that make them difficult to apply to this study. First of all, some of these theories conceptualize technology, users and organizations as distinct entities with inherent characteristics. Interaction between these entities is usually in the form of one impacting or moderating another (Orlikowski & Scott, 2008). For example, in HOT-Fit Model and D&M IS Success Model, System

Quality and Service Quality were presented as characteristics of technology that determine user intention and satisfaction. DeLone & McLean (2008) described System Quality as characteristics of the system that make it desirable such as usability, reliability, availability, response time and adaptability (pp. 24-25). They described Service Quality as “the overall support delivered by the service provider” and is measured using the following metrics: assurance; empathy; and responsiveness (p. 25). The model does not consider differences in user abilities, goals and other contextual factors that make the interaction with technology unique for users and their organizations. The quality and outcomes of technical support do not depend only on the metrics mentioned above, but also on the interaction between users and support personnel. The ability of support personnel to solve problems or add new features to a system depends on how clearly problems or needs are expressed and understood, and how responsive both parties are to each others’ limitations. In the CHEATS Framework, the Social construct was assessed in terms of how technology affects social contact within an organization (Shaw, 2002, p. 218), whereas social contact may precede technology use through the processes of technology development, procurement, training, adoption and modification. People determine what technology should be able to do and technology determines what people can do with it. People find innovative ways to use technology, some of which were not envisaged by the developers of that technology. In other words, technology, users and organizations are “interdependent systems that shape each other through ongoing interaction” (Orlikowski & Scott, 2008, p. 457).

Secondly, using some of these theories in contexts where people are using different devices and programs/apps becomes very complex and difficult to analyze. For example, with D&M IS Success Model and HOT-Fit and CHEATS frameworks, it might be very difficult to assign any net benefits or drawbacks observed to a particular technology in settings where a combination of technologies is in use. Indeed, in real-life health care settings, multiple technologies that perform specialized functions collaboratively or independently may be in use. In this situation, it may not be a problem if the goal of a study is to assess the entire system of people and technologies. However, in a context such as the one proposed in this study, where students might be brining their own technologies into the classroom and patient bedside, using these theoretical frameworks to analyze adoption and use behavior will be complicated.

Lastly, in TAM and its extensions discussed above, there is an underlying notion of intention to use technology as being in binary terms: to use or not to use. Technology use must be viewed as a process with different stages rather than a single endpoint. The Levels of Technology Implementation (LoTi) Framework, discussed earlier, recognized this problem and put forward a six-stage process for describing technology use among teachers in classroom settings (Moersch, 1995). Depending on the time at which assessment is made, use behavior may be different. For example, if after a period of using a system, a user finds out that the system does not meet her/his individual and organisational goals, she/he may discontinue use despite being competent at using it and jump onto another system that might provide better results. In this case, there is still productivity despite disuse of one particular technology. Another user in the same situation may keep using the system, although infrequently because perhaps it is mandatory to use it within the organization. Experience and voluntariness, therefore, are associated with adoption and use behavior. TAM2 caters for these factors quite well.

Considering these problems and stated aims of this study, it is important to use a theoretical framework that caters for the fact that (1) the study population consists of students who may or may not be using m-health in the school setting, (2) students using m-health are not likely to be using the same technologies, (3) students are likely to be at different stages of adoption/use of their chosen technologies, and (4) there may be slight contextual differences between students in different programs levels. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) has many strengths in this regard, in addition to overcoming all the issues raised regarding the frameworks examined above.

3.2.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

Despite the results obtained for TAM2, it was still found to be missing quite a lot and so was followed three years later with an amendment to TAM2, renamed the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) (Figure 3.8).

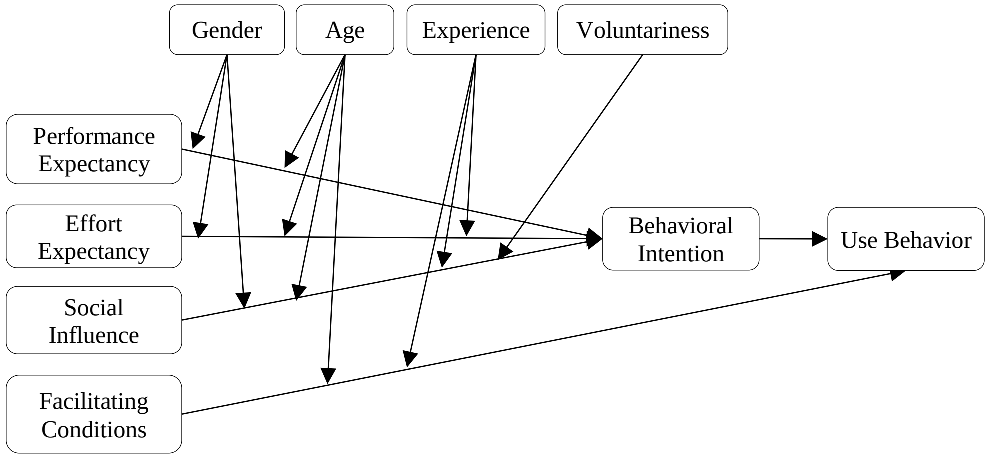

Figure 3.8: Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al*, 2003, p. 447)

Here, PU has been renamed Performance Expectancy (PE), which includes the constructs Extrinsic Motivation, Job-fit, Relative Advantage, and Outcome Expectations. PE is defined as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” (Venkatesh et al, 2003, p. 447). Effort Expectancy, defined as “the degree of ease associated with the use of the system” (p. 450) replaces PEOU, and includes the new constructs complexity and ease of use. Social Influence (SI), defined as “the degree to which an individual perceives that important others believe he or she should use the new system” (p. 451) is very similar to the SN construct of TAM2. In UTAUT however, SI encompasses the constructs SN, social factors, and image as used in related earlier studies (p.452). Lastly, Facilitating Conditions (FC), defined as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system” (p. 453) includes the constructs perceived behavioural control, facilitating conditions and compatibility. Importantly, FC accounts for some of the contextual nuances surrounding the use of technology. The presence of facilitating conditions alone will not necessarily enhance adoption and use of technology; rather, the user needs to be aware of the existence of these conditions and possibly experience them. In this model, PE, EE and SI influence Behavioral Intention (BI), while BI and FC predict technology use (Venkatesh, Thong, & Xu, 2012). Furthermore, Voluntariness and individual user level contextual factors Age, Gender and Experience moderate this relationship as show in Figure 3.8 above.

These constructs represent a very significant shift from the original TAM, in response to criticisms, and with an aim of providing a model that more accurately predicts user acceptance of technology. UTAUT has been shown to account for 70% of the variance in BI and about 50% in actual use (Holden & Karsh, 2010). Nonetheless, Bagozzi, one of the pioneers of TAM has criticized UTAUT for still missing very important predictors, despite encompassing "41 independent variables for predicting intentions and at least eight independent variables for predicting behaviour" (Bagozzi, 2007, p. 245).

Such criticisms, in addition to multitudes of studies employing UTAUT helped in its further development, leading to the development of UTAUT2 (Venkatesh et al., 2012). Importantly, this extension makes it more amenable to the study of consumer adoption and use behavior, as opposed to technology adoption and use within the organizational setting (p. 160).

In the new model (Figure 3.9), Voluntariness has been excluded because in the overall context of consumer technology behavior, technology choice and use is voluntary, unlike in many organizational settings (Venkatesh et al., 2012). This modification makes it more applicable to this research because none of the medical schools being studied has a formal m-health program, and therefore any use of m-health by students would be voluntary. Venkatesh et al. (2012) define Hedonic Motivation (HM) as “the fun or pleasure derived from using a technology” (p. 161) and this has been shown in a number of studies to directly predict technology acceptance and use. Thus, in UTAUT2, HM predicts BI. Unlike in the organizational setting, where users are often provided technology to use, the cost of initial purchase and device or service maintenance will be important in determining acceptance and use in the consumer context. Price Value (PV) is defined as “consumers’ cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them” (p. 161). The monetary costs, I would argue, would not be considered in absolute terms, but rather, in relation to the socioeconomic status of the consumer, since everyday experience shows that the amount of disposable income at a consumer’s disposal helps to determine the judgement of what is affordable or not. Lastly, Habit (HB) is defined as “the extent to which people tend to perform behaviors automatically because of learning” (p. 161). This is somewhat related to experience in the sense that habit develops with continual use and the passage of time since initial use. However, they are different because different habits develop with the passage of time and differing use rates of use (p. 161). Figure 3.9 illustrates the relationships between all the variables that form the model.

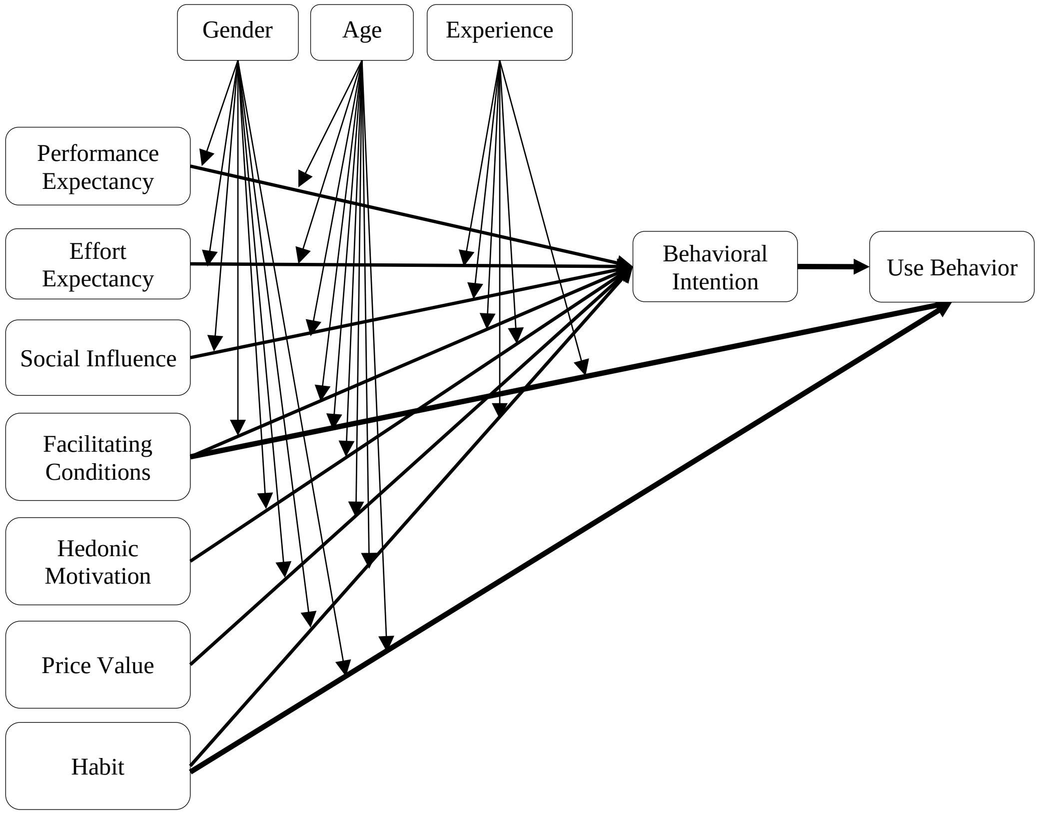

Figure 3.9: Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) (Venkatesh et al., 2012, p. 160)

3.3 Research Hypotheses

Based on the literature review, research questions and objectives, the following null hypotheses were formulated. For clinical year undergraduate medical students in Ghana,

i. $H_0$1: There is no significant relationship between gender and m-health use
ii. $H_0$2: There is no significant relationship between program level and m-health use
iii. $H_0$3: There is no significant relationship between school and m-health use
iv. $H_0$4: There is no significant relationship between socioeconomic status and m-health use
v. $H_0$5: There is no significant difference in frequency of m-health use in different learning contexts
vi. There is no significant relationship between each of the demographic variables and frequency of m-health use in the classroom
    a. $H_0$6a: There is no significant relationship between gender and frequency of m-health use in the classroom
    b. $H_0$6b: There is no significant relationship between program level and frequency of m-health use in the classroom
    c. $H_0$6c: There is no significant relationship between school and frequency of m-health use in the classroom
    d. $H_0$6d: There is no significant relationship between socioeconomic status and frequency of m-health use in the classroom
vii. There is no significant relationship between each of the demographic variables and frequency of m-health use during individual or group studies

a. $H_0$7a: There is no significant relationship between gender and frequency of m-health use during individual or group studies

b. $H_0$7b: There is no significant relationship between program level and frequency of m-health use during individual or group studies

c. $H_0$7c: There is no significant relationship between school and frequency of m-health use during individual or group studies

d. $H_0$7d: There is no significant relationship between socioeconomic status and frequency of m-health use during individual or group studies

viii. There is no significant relationship between each of the demographic variables and frequency of m-health use during clinical training or patient care

a. $H_0$8a: There is no significant relationship between gender and frequency of m-health use during clinical training or patient care

b. $H_0$8b: There is no significant relationship between program level and frequency of m-health use during clinical training or patient care

c. $H_0$8c: There is no significant relationship between school and frequency of m-health use during clinical training or patient care

d. $H_0$8d: There is no significant relationship between socioeconomic status and frequency of m-health use during clinical training or patient care

ix. Performance Expectancy has no effect on Behavioral Intention

a. $H_0$9a: Performance Expectancy has no direct effect on Behavioral Intention

b. $H_0$9b: Performance Expectancy has no direct effect on Behavioral Intention when moderated by age, gender and experience

x. Effort Expectancy has no effect on Behavioral Intention

a. $H_0$10a: Effort Expectancy has no direct effect on Behavioral Intention

b. $H_0$10b: Effort Expectancy has no direct effect on Behavioral Intention when moderated by age, gender and experience

xi. Social Influence has no effect on Behavioral Intention

a. $H_0$11a: Social Influence has no direct effect on Behavioral Intention

b. $H_0$11b: Social Influence has no direct effect on Behavioral Intention when moderated by age, gender and experience

xii. Facilitating Conditions has no effect on Behavioral Intention

a. $H_0$12a: Facilitating Conditions has no direct effect on Behavioral Intention

b. $H_0$12b: Facilitating Conditions has no direct effect on Behavioral Intention when moderated by age, gender and experience

xiii. Hedonic Motivation has no effect on Behavioral Intention

a. $H_0$13a: Hedonic Motivation has no direct effect on Behavioral Intention

b. $H_0$13b: Hedonic Motivation has no direct effect on Behavioral Intention when moderated by age, gender and experience

xiv. Price Value has no effect on Behavioral Intention

a. $H_0$14a: Price Value has no direct effect on Behavioral Intention

b. $H_0$14b: Price Value has no direct effect on Behavioral Intention when moderated by age, gender and experience

xv. Habit has no effect on Behavioral Intention

a. $H_0$15a: Habit has no direct effect on Behavioral Intention

b. $H_0$15b: Habit has no direct effect on Behavioral Intention when moderated by age, gender and experience

xvi. Behavioral Intention has no effect on Use

a. $H_0$16a: Behavioral Intention has no direct effect on Use

b. $H_0$16b: Behavioral Intention has no direct effect on Use when moderated by age, gender and experience

xvii. Habit has no effect on Use

a. $H_0$17a: Habit has no direct effect on Use

b. $H_0$17b: Habit has no direct effect on Use when moderated by age, gender and experience

xviii. Facilitating Conditions has no effect on Use

a. $H_0$18a: Facilitating Conditions has no direct effect on Use

b. $H_0$18b: Facilitating Conditions has no direct effect on Use when moderated by age, gender and experience

Chapter 4

4 Methodology

This chapter discusses the research design of this study—mixed-methods. It then provides details of the study's locations, population and sample, followed by a detailed account of materials and methods or techniques employed to obtain data from the locations and population. This is then followed by a detailed account of data management and analysis techniques employed. Lastly, it discusses ethical considerations.

4.1 Research methodology

Mixed methods research is commonly known to be research employing both qualitative and quantitative methods. Johnson and Onwuegbuzie (2004) defined it as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p.17). According to Johnson, Onwuegbuzie, and Turner (2007), it is "an intellectual and practical synthesis based on qualitative and quantitative research; it is the third methodological or research paradigm (along with qualitative and quantitative research)" (p.129).

Many reasons have been put forward in support of mixed methods research. According to Creswell (2014), the complex nature of social and health research problems makes quantitative or qualitative methods alone inadequate in effectively studying them (p. 203). Furthermore, the very nature of interdisciplinary research, drawing expertise from many disciplines along with their methodological preferences, makes mixed methods research an inevitable consequence of this type of collaborative research. He further stated that as mixed methods research combines the strengths of both qualitative and quantitative methods, studies employing mixed methods approaches provide a broader understanding of problems (p. 203). Traditional quantitative research generally revolves around “deduction, confirmation, theory/hypothesis testing, explanation, prediction, standardized data collection, and statistical analysis” while qualitative research generally revolves around “induction, discovery, exploration, theory/hypothesis generation, the researcher as the primary “instrument” of data collection, and qualitative analysis” (Johnson & Onwuegbuzie, 2004, p.18).

According to Greene, Caracelli and Graham (1989), mixed methods designs are used for five main reasons: triangulation; complementarity; development; initiation; and expansion. Triangulation refers to “the designed use of multiple methods, with offsetting or counteracting biases, in investigations of the same phenomenon in order to strengthen the validity of inquiry results” (p. 256). By complementarity, the authors referred to the use of both qualitative and quantitative approaches to study “overlapping but different facets of a phenomenon yielding an enriched, elaborated understanding of that phenomenon” (p. 258). By development, the authors referred to using one approach to inform the design or development (including sampling) of the second approach (qualitative before quantitative or vice versa) (pp. 259-260). Initiation involves the discovery or emergence of new interpretations or perspectives due to the contradictions or inconsistencies that might arise out of using the two approaches (p. 260). Lastly, expansion involves using the two approaches to widen the scope or breadth by examining various aspects of a phenomenon (p. 260).

This study employed the mixed methods approach combining a survey questionnaire (quantitative) and focus group discussions/interviews (qualitative) for students and interviews (qualitative) for faculty and staff members to achieve triangulation, complementarity, development and expansion. Specifically, the sequential use of quantitative and qualitative approaches was done to (a) enable verification and corroboration of information provided by study participants, (b) facilitate elaboration, enhancement and clarification of survey questions using qualitative data, (c) facilitate the selection of students to participate in interviews or focus group discussions, and (d) enable assessment of different perspectives of students' m-health use. According to Greene, Caracelli and Graham (1989), initiation may occur serendipitously, hence attention will be paid to any inconsistencies or contradictions in results regarding the process of m-health use by students, and attitudes of students, faculty and staff members to m-health use by students, obtained from the questionnaire, interviews and focus group discussions.

This study employed the sequential quantitative dominant subtype of mixed methods design (QUAN → qual). Johnson, Onwuegbuzie and Turner (2007) defined this subtype as "the type of mixed research in which one relies on a quantitative, postpositivist view of the research process, while concurrently recognizing that the addition of qualitative data and approaches are likely to benefit most research projects" (p. 124).

Therefore, qualitative data, in this context, were collected to provide further insights into the quantitative (Creswell, Plano Clark, Gutmann, & Hanson, 2003).

4.1.1 Research paradigm

Key paradigmatic assumptions of this study are that (1) what study participants experience when using mobile technology are unique to them and are shaped not only by what they experience individually, but in addition, by influences of their environments, which include people and technologies; (2) the researcher is an observer and would not want to influence participants' understandings of their own experiences but rather, try to capture them as they are; (3) factors such as the researcher's skills, participants' abilities to fully reconstruct their experiences and the researcher's own ability to make sense of these experiences may limit how detailed participants' true experiences will be captured. In light of the above, in terms of ontology—beliefs or assumptions about being and the nature of reality (Ponterotto, 2005, p. 127) and epistemology—"the study of knowledge, the acquisition of knowledge, and the relationship between the knower [research participant] and would-be knower [the researcher]" (p. 127), this study belongs on the post-positivist (PP) side of the paradigmatic spectrum. This paradigm is based on the belief that there exists a "real" reality although this can only be measured or perceived up to a certain extent (Lincoln & Guba, 2003, p. 256). It also positions the researcher as a separate objective party to the researched, and that owing to the belief that true reality cannot be fully grasped, research findings are held true so far as there is no evidence to render them otherwise (pp. 256-257).

4.1.2 Role of the researcher

I see myself as a student researcher at an intersection between biomedical, computer and social sciences. This is not a settling place to be considering the differences in research traditions held by these disciplines. I usually come to terms with my situation by telling myself that people are as much biological as they are social beings, and ICT is as much a part of their lives today more than it has ever been. A health professional or researcher cannot really separate these characteristics when caring for a patient assessing a patient during research.

In designing this study, collecting data and analyzing them, I believed that the students were able to describe their experiences with m-health. I believed that exploring these experiences in depth should be able to give me a more balanced idea of what they encountered. As a researcher, I sought not only to find broad common grounds in participants' experiences, but to also highlight any stark departures from it.

4.2 Study locations

There are seven schools offering medical education in Ghana. Out of this number, five had students in clinical years at the time of data collection namely, Kwame Nkrumah University of Science and Technology School of Medical Sciences (KNUST-SMS), University of Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine and Health Sciences (UDS-SMHS), University of Health and Allied Sciences School of Medicine (UHAS-SM) and University of Ghana School of Medicine and Dentistry (UG-SMD). Details about these institutions and their programs are provided in Section 1.4 of Chapter 1. Owing to delays in obtaining ethical clearance from UHAS Institute of Health Research, it was not possible to collect data at UHAS-SM. This study was therefore conducted at four out of the five eligible schools, namely, KNUST-SMS, UCC-SMS, UDS-SMHS and UG-SMD.

4.3 Study population, sampling and sample size

The study population for the questionnaire was undergraduate medical students in their clinical years in the four medical schools with clinical year students stated above. The study population for the qualitative aspect was students who completed the questionnaire, faculty members, staff of the selected medical schools in Ghana.

Convenience sampling is a non-probability sampling method in which participants are recruited based on their availability or willingness to participate. All students who fit the eligibility criteria described above were invited to complete the study questionnaire. Therefore, respondents were self-selected to participate in this study. Among the advantages of this method is that respondents would be students who are interested in the study topic, and hence would be motivated to provide a lot of information. On the other hand, this method has the risk of introducing bias in the sample because students who choose to participate may share certain characteristics in common. Students who choose not to participate may share a difference set of characteristics, which may be missed in the study. This can infringe on the generalizability of findings to the study population. To prevent this problem, I ensured that every student in the study locations was aware of the study and had an equal chance of participating. This helped to minimize the risk of missing any significant subgroups.

The effect size of m-health adoption and use was computed using product indicator Partial Least Squares (PLS) regression, in accordance with Venkatesh et al., (2003, 2012). Studies by Chin, Marcolin, and Newstead, (1996) show that at a sample size of 100 and with four indicators per construct, it is possible to estimate a direct effect size of up to 86.8% of the true effect at a one-tailed significance level of 0.01. For the same sample size and indicator numbers, it is possible to detect an interaction effect of about 82.4% of the true effect at a one-tailed significance level of 0.05. A sample size of at least 250 was sought to enable better effect size estimation and to cater for the effects of missing data.

Purposive sampling was used to obtain participants for focus group discussions (FGDs) where feasible, while convenience sampling was used otherwise. One-on-one interviews were conducted where FGDs were not possible, such as where participants were reluctant to participate or where it was difficult to schedule discussions at a time that suited participants. In this situation, the FGD guide that applied to the participant's group was used for one-on-one interviews. For each school, the study aimed at having the following number of focus group discussions or interviews: two (2) for students; two (2) for faculty members; and two (2) for staff members. Therefore, for four medical schools, there would be a total of 24 FGDs or interviews to be conducted. However, owing to limited time on the field, only two FGDs and three interviews were conducted for students. One focus group had three participants while the other had four. In addition to this, interviews with five staff members comprising of an administrator, a librarian and three IT personnel were conducted. Lastly, seven faculty members in different departments were interviewed.

4.4 Data collection procedures

In accordance with the mixed methods design, quantitative data were obtained using an online or paper-based questionnaire, while qualitative data were obtained through semi-structured focus group discussions or interviews. Data collection occurred over a period of eight weeks from November 2017 to January 2018. For clinical year medical students, data were collected in a two-stage process involving the administration of questionnaires, followed by focus group discussions or interviews. Further details of how this was conducted are provided in the next section.

Prior to data collection, the survey questionnaire was developed and piloted among a total of nine clinical research assistants and resident doctors in Ghana. Owing to the fact that the data collection was going to be performed using identical online and paper-based questionnaires, piloting was done for both formats. Five pilot-participants completed the online questionnaire while five completed the paper questionnaire (one resident doctor completed both the online and paper questionnaires). Information obtained from this pilot enabled a few modifications to be made in response choices and wording of some questions. Owing to the fact that participants for the pilot were significantly different from the study population, pilot data were not included in the final analysis.

4.5.1 Survey questionnaire

The questionnaire was created following the guidelines developed by Laurillard (2007), and adapted survey tools used by Davies et al. (2012), Ellaway et al. (2014), Scott et al. (2017), Venkatesh et al. (2012) and Wittich et al. (2016).

The first section of the questionnaire collected demographic information about participants such as age, gender, and year of study. The remaining sections were structured based on the study objectives. Close-ended questions were used to collect data in the form of categorical options or continuous variables. Five-point Likert-type questions and Likert scales (Boone & Boone, 2012) were used in collecting participant responses to questionnaire items that gauged the degree to which they agreed or disagreed with a statement, their degree of satisfaction or the frequency with which they used technology (Sezgin & Özkan-Yildirim, 2016). The Likert-type questions involving agreement or disagreement included a “neutral/don’t know” option for respondents who were not sure about a specific response. The questionnaire was designed mainly to gather quantitative data, so most questions provided options for participants to choose from. Recognizing that it is not possible to include all conceivable response options for every question, many questions included an open ended “Other” option. In addition, space was provided for respondents to name specific standard treatment guidelines or medicines formularies that they used. The questionnaire contained 39 main questions, with sub-questions ranging from two to eighteen (18). These questions were organized into seven sections as follows:

i. Section A: General information;
ii. Section B: Technology access;
iii. Section C: Types of m-health and the contexts within which they are used;
iv. Section D: Uses of m-health;
v. Section E: Impact of m-health;
vi. Section F: Enablers and barriers;
vii. Section G: Attitudes towards m-health use;

An online questionnaire was developed using Qualtrics Research Core software (Qualtrics, n.d.) that Western University has made available to its research community. The questionnaires were preceded by a letter of information and consent. Participants were required to check a box confirming that they have read the information and consent to participate before they could proceed to the survey questions. For all students, completing the survey implied that they had consented to participate in the survey. A sample of the questionnaire and other study instruments are provided in the Appendices. These instruments were initially developed to collect data from both medical and dental students in Ghana. However, since only five dental students from UG-SMD and none from KNUST Dental School responded to the questionnaire. This number was too small to enable findings to be generalized to dental students, therefore dental students were excluded from this study.

Strategies used to administer questionnaires were adapted to suit contexts at each school and year of study. Paper questionnaires were distributed in class, while the web address to the online questionnaire was distributed using SMS text or Whatsapp groups. This enabled the questionnaire to reach as many students as possible.

At UDS-SMHS, preliminary enquiries suggested that internet connectivity was sometimes poor, so paper questionnaires were administered for first and second clinical year students. This was possible because these students attended classes once a week at the Tamale Teaching Hospital (TTH), where they also undertook clinical training. At the time of data collection, third clinical year students at UDS were on break and so could not be reached at the teaching hospital nor at the main university campus. The web address to the online questionnaire was sent to the course representative for the year group, who subsequently circulated it on their Whatsapp group.

At UG-SMD, preliminary enquiries suggested that students were more responsive to circulars sent through Whatsapp groups compared to emails. The administrator therefore forwarded the online questionnaire web address to class representatives for each clinical year group for onward circulation via their respective Whatsapp groups.

At UCC-SMS first clinical year students were writing exams in the week of data collection at that study location. As a result, the online questionnaire web address was sent to the class representative, with the help of an administrator at the Clinical Teaching Centre (CTC) attached to the Central Regional Hospital. The class representative then circulated the web address on the class Whatsapp group. Second clinical year students received paper questionnaires at the end of a class. A group of 11 third clinical year students attending a seminar at the CTC also received paper questionnaires, which they returned to the administrator, who then forwarded them to me by post.

Ethical clearance for KNUST-SMS was obtained on the university's last working day before the Christmas/new year break. School was scheduled to resume on January 12, 2018, three days after I was scheduled to return to Canada for the winter term in order to fulfill my teaching assistant duties. As a result, with the assistance of the Information Technology Directorate of the university, the web address for the online questionnaire was circulated to all clinical year medical and dental students via the directorate's SMS text platform.

Ethical clearance for UHAS-SM was received after I had left the field and efforts to get the school's registrar to circulate recruitment emails were unsuccessful. Table 4.1 summarizes questionnaire administration strategies and response rates. A total of 828 students received paper questionnaires or links to the online questionnaire. Out of this, 291 questionnaires were returned.

Table 4.1: Questionnaire administration strategies and response rates

School	Questionnaire type	Method of dissemination	Number of students reached	Number of completed questionnaires	Response rate
KNUST-SMS & -DS	Online	SMS	179	5	2.6%
UCC-SMS	Paper	In-class	71	56	78.9%
	Online	Whatsapp	67	0	0%
UDS-SMHS	Paper	In-class	229	156	68.1%
	Online	Whatsapp	82	24	29.3%
UG-SMD	Online	Whatsapp	200	50	25.0%

For students attending classes, I sought permission from their instructors or class representatives at the end of class, to introduce the study to students and invite them to participate. Students were informed that participation was voluntary and therefore they were free to not participate. Questionnaires were placed on the first desk of each seating column, and students were asked to pass them to anyone who wanted to participate. I was stationed in front of the class for a few minutes to answer any questions, then outside the classroom. Students called me in to return their completed questionnaires or handed them to their class representatives.

4.5.2 Focus group discussions and interviews

Semi-structured FGDs and interviews were used to allow me to clarify findings of the questionnaire survey and seek answers to specific issues, while allowing participants to freely express their thoughts and experiences, allowing issues that were important to them to emerge (Duffy, Ferguson, & Watson, 2004). Semi-structured interviews are usually guided by pre-determined questions that ensure that information is gathered regarding specific issues. An interview guide made up of statements focusing broadly on the specific objectives of this study was used to guide the interviews. These guiding statements are provided in Appendices D, E and F.

Students completing the online questionnaire were asked to indicate at the end of the letter of information and consent (LOIC) if they wished to be contacted to participate in the FGDs/interviews and to provide contact phone numbers and/or email addresses. Those completing paper questionnaires were asked to indicate same and provide phone numbers and/or email addresses at the end of their questionnaires. Students who were readily available after administration of in-class paper questionnaires i.e. students at UCC-SMS and UDS-SMHS were immediately engaged in FGDs/interviews after completing their questionnaires. For those that opted to participate in FGDs/interviews at UG-SMD, students were grouped based on clinical years and invited. Only one person showed up on each day, so interviews were conducted with those participants. Faculty members teaching clinical year students were purposively sampled from different departments so that in the end, as many departments were obtained as possible across the five schools. Due to the busy schedules of faculty members, especially clinical tutors, only interviews were held for this group. Key faculty members involved in e-learning and m-learning efforts were actively sought and interviewed. Lastly, key non-academic staff members comprising of an administrator, IT support staff and a librarian were also interviewed.

All FGDs and interviews were conducted by the researcher and the language of conversation was English. Interviews and FGDs with students were held in public areas outside lecture halls or libraries at UCC-SMS and UDS-SMHS. At UG-SMD, one interview was held in the conference room of the school's Research Office, while the other was held in a public area outside the school's main administration building. Interviews with faculty and staff members were held in their offices. Care was taken to choose locations where activities going on in the environment did not distract the FGDs or interviews.

All FGD and interview participants were given informed consent documents to review prior to the start of interviews. Any questions regarding informed consent were addressed before interviews began. In addition, by providing their contact information prior to completing the survey, students attending FGDs/interviews would have already provided their consent. A signed letter of information and consent was obtained from each participant before interviews or discussions began. Throughout the study, participants were reminded of their freedom to withdraw from the study or withdraw part of the data they had provided. Participants were also made aware of the fact that whatever they told the researcher, whether during FGDs, interviews or informal conversations may be used as data for the study unless they explicitly requested the information to be excluded from the study. This helped ensure good ethics in the study (Tracy, 2010).

I used active interviewing skills to help ensure good quality data (Rubin & Rubin, 2005). These included techniques such as active listening skills using body language, paraphrasing main ideas from what interviewees had said and probing issues of interest further with more specific follow-up questions. Notes were taken regarding the participants' behaviours during interviews. Facial expressions, hand gestures, moments of surprise, worry, silence, etc. were actively sought and recorded. These were considered as part of the data and were analysed together with interview transcripts.

All FGDs were recorded using a voice recorder. FGDs and interviews lasted less than 60 minutes each. Recordings were transcribed and analyzed according to procedures described in section 4.7 below.

4.6 Data handling

All study data and electronic documentation were stored and backed up on password-protected external hard disc drives. During all transportation, data were continuously supervised and taken directly from site to site. In Ghana, when not traveling, all completed paper questionnaires, consent forms and audio recordings (stored on an encrypted external hard drive) were kept in a locked cabinet in my secure office at the Centre for Tropical Clinical Pharmacology & Therapeutics, University of Ghana School of Medicine and Dentistry. In Canada, the backup hard disc drives were kept in a locked cabinet in the secure office of the principal investigator (supervisor). All paper documents such as signed consent forms, memos and the field notebook were also stored in a locked cabinet in the secure office of the principal investigator. All data will be stored for seven years in accordance with the University of Western Ontario Faculty Collaborative Agreements Research Data Retention Policy. Electronic data will be permanently purged according to institutional guidelines at the time of data destruction. All paper documents will have identifiable information blacked out using a black permanent marker. The documents will then be shredded and recycled.

4.7 Data analysis

4.7.1 Quantitative data analysis

Nominal variables were summarized into frequencies and percentages (e.g. gender and school) and the main measure of central tendency discussed was the mode. Continuous variables such as age were summarized as means. The main grouping variables were gender, program level, school and socioeconomic status. The variable program level was constructed out of the variable year of study because different schools have different designations for clinical years. For example, at UDS-SMHS, Level 500 is the first clinical year while at UCC-SMS and UG-SMD, it is Level 400. Descriptive statistics for Likert-type questions were presented as frequencies and percentages because they were ordinal data. As such, the main measures of central tendency highlighted were medians and modes (Boone & Boone, 2012).

The first part of the hypothesis testing involved three dependent variables: (1) frequency of desktop computer use; (2) m-health use status; and (3) frequency of m-health use. Frequency of m-health and desktop computer use are ordinal variables with five levels each: "never;" "sometimes;" "about half the time;" "most of the time;" and "always". Frequency of m-health use was measured in three contexts, namely, classroom, during individual or group studies and during clinical sessions or patient care. This allowed assessment of its context-specific relationships with independent variables. M-health use status is a nominal variable with binary outcome: yes or no.

Relationships between categorical independent variables and m-health use status were assessed using chi-squared tests. Fisher's Exact test was used where a cell in the cross tabulation had less than five observations. To determine if students used mobile technologies in place of desktop and laptop computers, a comparison of proportions z-test was performed. Comparing frequencies of m-health use in the three contexts mentioned above for the same respondents involved matched data, therefore this was done using Friedman test. Wilcoxon-Mann-Whitney rank-sum test was used where independent variables had two levels (i.e. gender) and the dependent variable was ordinal and had more than two levels (i.e. frequency of m-health use). Kruskal-Wallis test of equality of proportions was used where independent variables had more than two levels (i.e. program level, school and socioeconomic status) and the dependent variable was ordinal and had more than two levels (i.e. frequency of m-health use, frequency of desktop computer use).

All quantitative data analyses were performed using Stata 13 (StataCorp, 2013). The TAB_CHI package (Cox, 2016), specifically the `tabm` command was used for summarizing (tabulating) variables with multiple responses such as devices owned, operating systems used and how students learned about new m-health technologies.

Structural Equation Modeling

Analysis of variance (ANOVA and MANOVA), analysis of covariance (ANCOVA and MANCOVA) and multiple regression (including moderated multiple regression) can be used for structural equation modeling (SEM). However, there are a number of problems associated with each of these methods. For example, analyses of variance and covariance do not usually provide effect size (eta squared) and this is often calculated by hand from the sum of squares (Chin et al., 1996). With regression, the level of reliability of any effect size obtained for interaction terms is often much lower than that of the individual variables, and this has an impact on the kinds of conclusions that can be made from studies employing this method (p. 22). In short, using these methods is not only cumbersome, but can affect reliability of findings.

There are two main approaches for evaluating structural equation models such as UTAUT2, namely, covariance-based SEM (CB-SEM) and partial least squares (PLS) path modeling (variance-based SEM) (Henseler & Chin, 2010). According to Hair, Ringo and Sarstedt (2011) the two approaches complement each other. While CB-SEM's strengths lie in establishing structural relationships between variables, PLS-SEM's strengths lie in predicting and explaining the role of variables in a model. According to Hair, Sarstedt, Pieper, and Ringle, (2012),

> PLS-SEM is particularly appealing when the research objective focuses on prediction and explaining the variance of key target constructs (e.g., strategic success of firms) by different explanatory constructs (e.g., sources of competitive

advantage); the sample size is relatively small and/or the available data is non-normal; and, when CB-SEM provides no, or at best questionable, results (p. 321).

PLS is particularly good evaluating models where variables (latent variables) in the model are not measured directly but are rather constructed out of measurement or indicator variables (Henseler, Hubona, & Ray, 2016). This combination of variables is generally associated with a certain amount measurable error that PLS takes into account (Chin et al., 1996). Furthermore, unlike regression, PLS does not assume that indicator variables contribute equally to a latent variable. Rather indicators are weighted so as to obtain the best correlation between indicator and latent variables and the highest explained variance for indicators and latent variables (pp. 25-27). To assess the effects of moderators, product indicators for every combination of indicators for the latent variables involved (predictor and moderator) are constructed, weighted and used in the model (p. 27). This is the product indicator approach of PLS.

Underlying PLS is multiple regression. As such, in a situation where each latent variable is constructed from a single indicator, running PLS gives the same results as running multiple regression (Chin et al., 1996, p. 27). How close a sample estimate gets to the population effect size increases with increasing number of indicators and almost plateaus off at around six to eight indicators, for any given sample size (Chin et al., 1996; Henseler & Chin, 2010). Also, increasing the number of indicators increases the power of the study (Chin et al., 1996, p. 31).

Sample size generally increases the consistency of the estimate. Therefore, for multiple samples of the same size taken from the same population, estimated effect sizes will be closer to each other with increasing sample size. As such, with larger sample sizes, smaller effect sizes can be detected more accurately (Chin et al., 1996, p. 29). With these features of product indicator PLS, the authors showed using simulations that at a sample size of 100 and with four indicators per construct, it is possible to estimate a direct effect size of up to 86.8% of the true effect (p. 29) at a one-tailed significance level of 0.01 (p. 30). For the same sample size and indicator number, it is possible to detect an interaction effect of about 82.4% of the true effect (p. 29) at a two-tailed significance level of 0.05 (p. 30). Henseler and Chin (2010) recommend the product indicator PLS approach at medium to large sample sizes (>150) and measurement variables (6-8) because it provides high prediction accuracy and high statistical power. Venkatesh, Morris, Davis and Davis (2003) and Venkatesh, Thong and Xu (2012) used product indicator PLS path modeling to analyze UTAUT and UTATU2 respectively.

All latent variables in UTAUT and UTAUT2 except Use were constructed using reflective indicators (Venkatesh et al., 2003, 2012). Reflective indicators are indicators that reflect the state of their latent variable. Therefore, a change in the latent variable manifests in the indicator (Hair et al., 2011). Use was constructed using formative indicators. Formative indicators on the other hand, have a causal relationship with their latent variables, therefore, a change in the indicators cause the latent variable to change (p. 141). In this study, PLS path modeling was conducted using SmartPLS 3 (Ringle, Wende, & Becker, 2015). According to the authors, reflective indicators should be modeled with arrows pointing towards them and away from the latent construct, while formative indicators should have arrows pointing away from them and towards the latent construct. When arrows are pointing away from a latent construct, PLS computations are done using Mode A, while when arrows are pointing towards a latent construct, computations are done using Mode B. The difference between the two modes is that in Mode B, regression weights are used in computations, thus taking into account collinearity among predictors, while in Mode A correlation weights are used thus ignoring collinearity. Becker, Rai, and Rigdon (2013) contend that this coupling of reflective models to Mode A and formative models to Mode B is limiting. Their argument is that both modes A and B involve forming composites i.e. latent variables or constructs are constructed out of indicators in the first place therefore it is correct to analyze a formative model using Mode A. Indeed, they quote several studies that show that using correlation weights provides similar or better results than regression weights (p. 6). Furthermore, based on Henseler et al., (2016) since the research question in assessing the validity and reliability of a formative construct is more of "does it make sense for the construct to be made out of the indicators," collinearity should not be allowed to constrain how the model is measured once there is logical and theoretical reason to build the construct using the chosen indicators. In this study, all latent variables were modeled using Mode A.

In this study, there were 221 m-health users in total. As with any study of this nature, missing data cannot be totally avoided. Missing data were handled using case-wise deletion, reducing the final sample to 100. Using mean imputation to handle missing data would have maintained the sample size, however, this method significantly reduced the explained variance for latent variables and therefore path coefficients between latent variables. For direct effects, each latent variable was constructed using three to seven items/indicators as shown in Table 4.2 below. All items were measured using five-point Likert-type scales.

For moderated effects, Age, Gender and Experience were added to the model. After case-wise deletion, the final sample size was 94. Age is a ratio variable and was used as such, while Gender was recoded to a 0/1 variable with 1 referring to females. Experience, being a categorical moderator of the nominal type with six levels (i.e. ≤ 3 months, 4-6 months, 7-12 months, 1-2 years, 2-3 years and ≥3 years) was reduced to four levels of equal intervals. The variable was then included in the model to form the moderator Experience, (Henseler et al., 2016, p. 7). Table 4.2 lists initial indicator variables used in the model, most of which were adapted from Venkatesh et al. (2012). A list of final indicators is provided in chapter 5.

Table 4.2: Measurement items/indicators

Latent Construct	Items/Indicators
Performance Expectancy	PE1. I find m-health technology useful in my school life. PE2. Using m-health enables/motivates me to improve my clinical knowledge and skills PE3. Using m-health technology helps me accomplish things more quickly. PE4. Using m-health technology increases my productivity. PE5. Using m-health enables/motivates me to apply what I have learned to clinical practice
Effort Expectancy	EE1. Learning how to use m-health technology is easy for me. EE2. My interaction with m-health technology is clear and understandable. EE3. I find m-health technology easy to use. EE4. It is easy for me to become skillful at using m-health technology.

Latent Construct	Items/Indicators
Facilitating Conditions	FC1. I have the resources necessary to use m-health technology. FC2. I have the knowledge necessary to use m-health technology. FC3. M-health technology is compatible with other technologies I use. FC4. I can get help from others when I have difficulties using m-health technology.
Price Value	PV1. M-health technology is reasonably priced. PV2. M-health technology is a fair value for the money. PV3. At the current price, m-health technology provides a fair value.
Social Influence	SI1. People who are important to me (e.g. tutors, colleagues, patients, carers) think that I should use m-health technology. SI2. People who influence my behavior think that I should use m-health technology. SI3. People whose opinions that I value prefer that I use m-health technology.
Hedonic Motivation	HM1. Using m-health technology is fun. HM2. Using m-health technology is enjoyable. HM3. Using m-health technology is very entertaining.
Habit	HT1. The use of m-health technology has become a habit for me. HT2. I am addicted to using m-health technology. HT3. I must use m-health technology. HT4. Using m-health technology has become natural to me.
Behavioral Intention	BI1. I intend to continue using m-health technology in the future. BI2. I will always try to use m-health technology in my school life. BI3. I plan to continue to use m-health technology frequently. BI5. I will use m-health if introduced in the school curriculum BI5. I will use m-health for patient care if I encounter it in the work setting.
Use	How frequently do you use m-health technologies in the following contexts? • U1. In the classroom • U2. During individual or group studies • U3. During clinical sessions or patient care How frequently do you use the following m-health functions, apps or programs? • U4. Phone calling (dropped • U5. SMS • U6. Photo gallery or similar app/program • U7. Video player/streaming • U8. Web browser • U9. Medicines formulary (please specify) • U10. Standard treatment guidelines (please specify)

4.7.2 Qualitative data analysis

The main sources of qualitative data for this study were interview and focus group discussion transcripts. Given that the role of qualitative data in this study was to elaborate on information gathered through the survey, thematic analysis was the best approach to analyzing these data. According to Braun and Clarke (2006), thematic analysis is a method involving the search for themes or patterns from a data set of interviews without necessarily formulating a theory out of those themes.

In line with Braun and Clarke's (2006) steps, analysis began with familiarization with the data whereby audio-recorded interviews and focus group discussions were transcribed and read. During this process, memos were made of initial patterns observed. Following this, initial codes were developed for the data, based on notes made in the previous step, and while reading the transcripts again. Coding was performed using NVivo 11 for Windows (QSR International Pty Ltd, 2015) by creating nodes for initial codes generated. Transcripts and memos were carefully studied for patterns, and how actions may have changed, or issues may have been dealt with over time. Sections of transcripts were coded by assigning them to existing NVivo nodes or by creating new nodes. Care was taken to ensure that coded text had enough contextual information to make them meaningful if isolated. Texts that fitted into more than one code were assigned to all the relevant NVivo nodes. After coding was complete, codes were collated into groups based on their similarities and those that were very similar were combined into lower-level themes. Codes that stood alone became themes by themselves. Themes were then defined. Relationships between themes were then mapped out and verified by going back to the data and where necessary, the linkages were amended. Each lower-level theme was placed under one of four broad higher-level themes under which the study objectives were organized, namely (1) Types and uses of information technology and m-health, (2) impact of m-health use, (3) facilitating conditions of m-health use, and (4) attitudes towards m-health use. During this process, some lower-level themes were combined while others were split up in order to ensure they fit perfectly under higher-level themes. Theme definitions were updated to reflect these changes. For example, some of the text that had initially been coded under “uses” was taken out to create a new theme called “use frequency,” to enable elaboration of survey findings regarding use frequency. Similarly, texts that had initially been coded under “time” were split to create the themes “time saving or maximization” and “time wasting.” “Time wasting” was then combined with “distraction” because in all the instances where m-health was associated with time wasting, distraction was the main cause.

4.8 Ethical considerations

Based on criteria specified by the Human Research Ethics Board of the University of Western Ontario, ethical approval for this study was sought from the Health Sciences Research Ethics Board (HSREB) (Delegated Review) of the university. Additional ethical approval was obtained from three of the study locations, namely, Kwame Nkrumah University of Science & Technology School of Medical Sciences (KNUST-SMS), University of Health & Allied Sciences School of Medicine (UHAS-SM) and University of Ghana School of Medicine and Dentistry (UG-SMD).

Participation in this study was voluntary and participants were reminded of this throughout the study. Letters of information and consent (LOIC) were prepared for each study group, namely, students, faculty and staff. Samples of these documents are provided in the Appendices. All participants provided informed consent before participating in this study.

4.8.1 Benefits

Participants were made aware that they may not benefit from this study at all. Through participation in this study, students, faculty members and non-academic staff of the study institutions may have become aware of new technologies and methods of instruction and learning.

This study will contribute evidence from the Ghanaian context, regarding the use of m-health by medical students. The knowledge generated from this study might be useful in aiding in the development of effective modes of introducing e-health and m-health into medical education curricula.

4.8.2 Potential risks

No identifying information was collected from participants except those that opted to participate in focus group discussions (FGDs). For these participants, first names, email addresses and phone numbers were collected in order to facilitate organization of interviews or FGDs. This information is being kept confidential. It is not possible to ensure anonymity for all FGD participants. It is not possible to guarantee a breach of privacy will not occur for all aspects of this study. For example, it is not possible to ensure that FGD participants will keep discussions confidential. Nonetheless, measures outlined in the LOIC to minimize any risks to participants were followed strictly.

In terms of procedural ethics, I frequently reminded participants that their involvement in the study was voluntary and therefore they were free to opt out at any point, including after data collection was over. I did not have access to the student Whatsapp groups. Interview recordings and transcripts were identified using code numbers, and a master list linking code numbers to questionnaires is kept in an encrypted Microsoft Excel document, separate from the study data. No photographs or video recordings of participants were taken. In analyzing and reporting FGDs and interviews, participants were referred to by their code numbers to protect their identities.

In terms of relationship ethics, I will not maintain contact with participants outside activities of data collection outlined in the preceding sections of this chapter. I made conscious efforts to ensure that any interaction with students did not adversely influence the data they provided or their ongoing studies. All of the above, together with other ethical considerations embedded in the study methods helped to ensure protection of participants and data collected from them, as well as help ensure study quality.

4.8.3 Incentives and compensation to participants

To avoid a risk of coercion, no incentives or compensation was provided to participants. FGDs, interviews and the survey were conducted within the educational setting, hence there were no extra transportation costs to participants. Each study location provides internet access to students, faculty and staff members, hence there was no anticipated extra cost associated with completing the survey online. Students who chose to complete the paper-based questionnaire will be asked to return them later if they so wished.

Chapter 5

5 Quantitative research findings

In this chapter, findings obtained from the quantitative analysis of the survey data are presented. Overall, 291 questionnaires were returned. However, only five students from KNUST-SMS returned their completed questionnaires, while none from KNUST-DS did. As a result, both schools were excluded from the first part of the analysis. Similarly, only five dental students from UG-SMD responded to the questionnaire making it difficult to arrive at any meaningful conclusions regarding dental students' use of m-health. Therefore, these five questionnaires were also excluded from the analysis. As a result, 281 returned questionnaires, representing data obtained from three schools, namely, UCC-SMS, UDS-SMHS and UG-SMD were included in the first part of the quantitative analysis. Since the second part of the quantitative analysis involving structural equation modeling did not involve comparisons between schools, data from KNUST-SMS were included in that analysis.

5.1 Descriptive analysis

5.1.1 General Information

There were slightly more males (53%) than females (47%) in this study (Figure 5.1). Ages ranged from 19 to 40 years with most of the students falling within the age group of 20-29 years. The mean age was 24.2 years with standard deviation of 2.4 years.

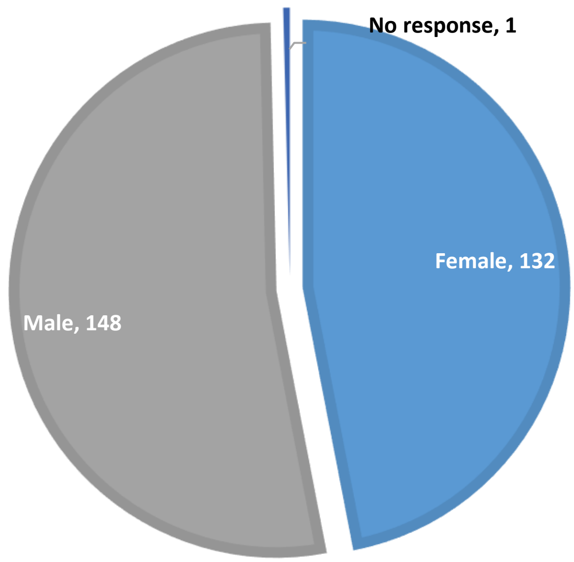

Figure 5.1: Distribution of students' gender

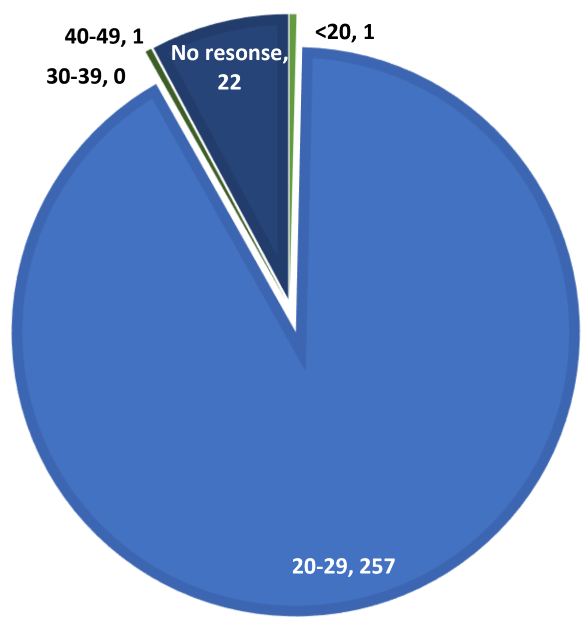

Figure 5.2: Age distribution of students

About two-thirds (64%) of the students surveyed were from UDS-SMHS (Figure 5.3).

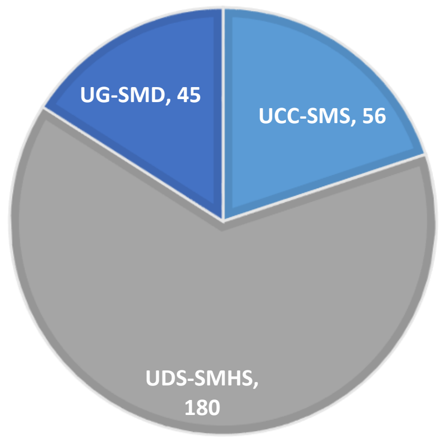

Figure 5.3: Distribution of students according to schools

Most students surveyed were medical students in their first or second clinical years (Figure 5.4 & Table 5.1). Third clinical year students were difficult to reach because they were on holidays (UDS-SMHS) or were split into smaller clerkships that did not have regular classroom hours.

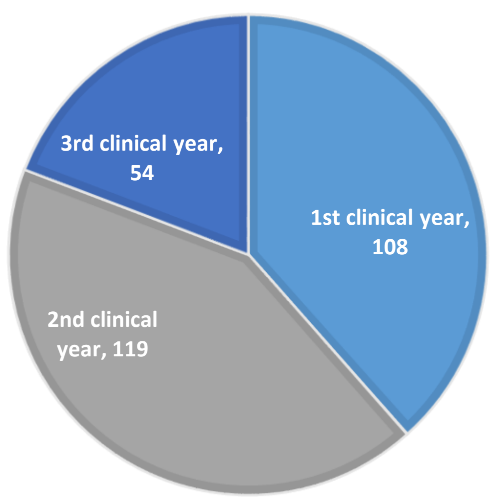

Figure 5.4: Distribution of students according to program level

Table 5.1: Program level distribution of students according to schools

Program level	UCC-SMS	UDS-SMHS	UG-SMD
1st clinical year	0 (0%)	85 (47.2%)	23 (51.1%)
2nd clinical year	45 (80.4%)	71 (39.4%)	3 (6.7%)
3rd clinical year	11 (19.6%)	24 (13.3%)	19 (42.2%)

There were slightly more male respondents at UCC-SMS and UDS-SMHS than females (Table 5.2). However, at UG-SMD, it was the reverse; there were slightly more female respondents.

Table 5.2: Gender distribution of students according to schools

Gender	UCC-SMS	UDS-SMHS	UG-SMD
Female	26 (46.4%)	82 (45.6%)	24 (53.3%)
Male	30 (53.6%)	98 (54.4%)	20 (44.4%)
No response	0 (0%)	0 (0%)	1 (2.2%)

Median family income was GHS2,000 – 4,999 per month (CAD545 – 1,355), with over half of students surveyed choosing not to answer this question (Figure 5.5).

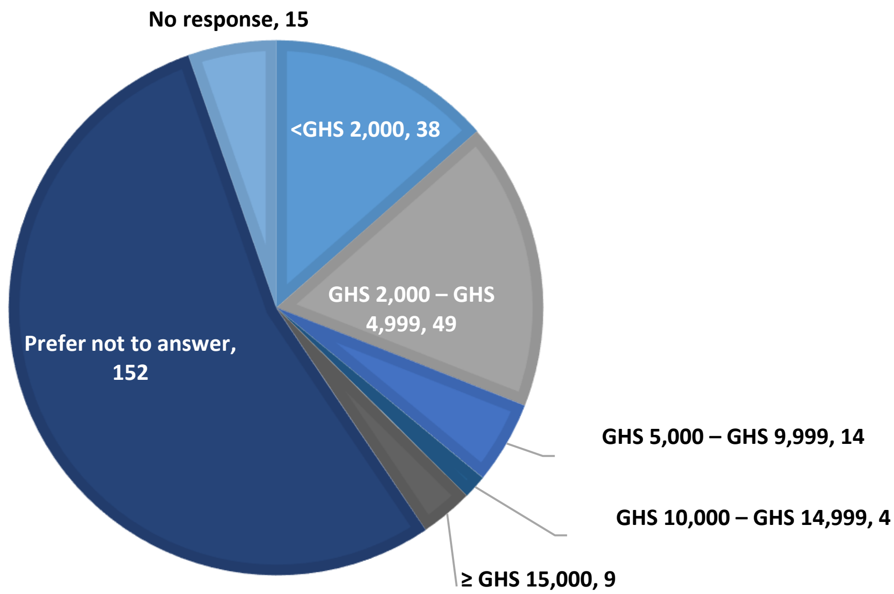

Figure 5.5: Estimated monthly incomes of students' families

5.1.2 Types and uses of information technology and m-health, and the contexts within which they are used

5.1.2.1 Technology access and types of m-health

Although only about a third of students owned a desktop computer (Figure 5.6), almost three-quarters of students had access to one (Figure 5.7). Access to desktop computers was possible through computer labs at the various universities. The largest proportion of students (47.3%) used a desktop computer "sometimes" (Figure 5.8). Only about 12% of students used desktop computers always.

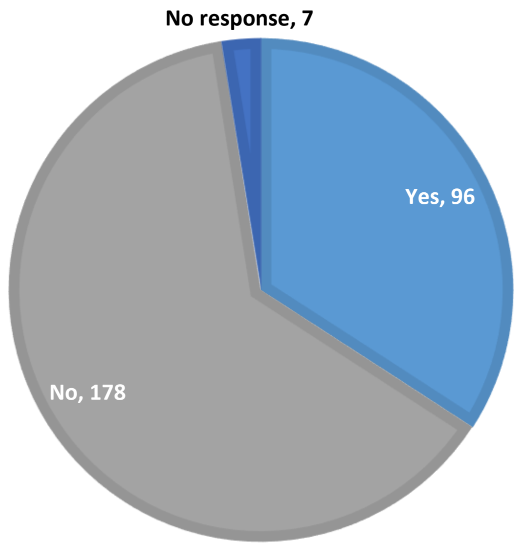

Figure 5.6: Ownership of desktop computers by students

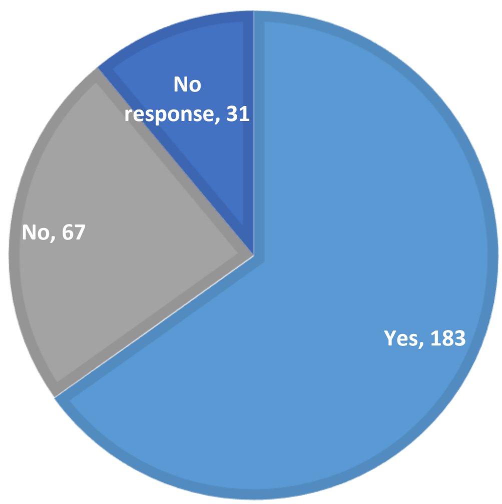

Figure 5.7: Students' access to a desktop computer

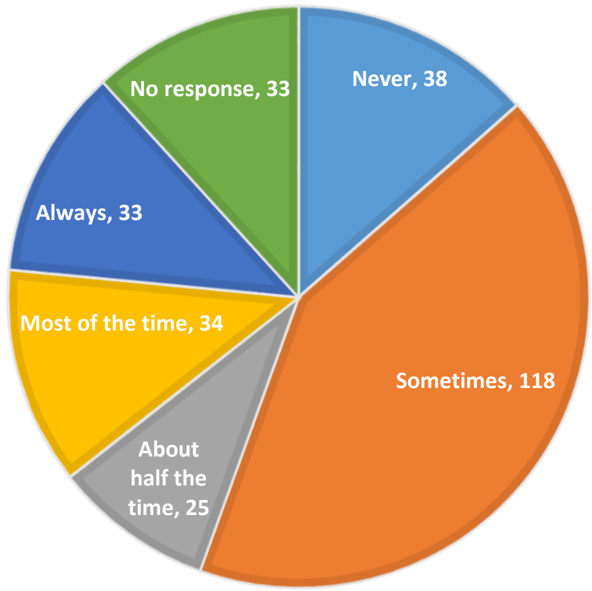

Figure 5.8: Frequency of desktop computer use by students

Most students used mobile devices in place of their desktop and laptop computers. About 72% of students "somewhat agreed" or "strongly agreed" that they used mobile devices in place of desktop computers (Figure 5.9) while about 64% "somewhat agreed" or "strongly agreed" that they used other mobile devices in place of their laptops (Figure 5.10). The median response for substituting desktop computers with mobile devices was "strongly agree" while that for substituting laptops with mobile devices was "somewhat agree."

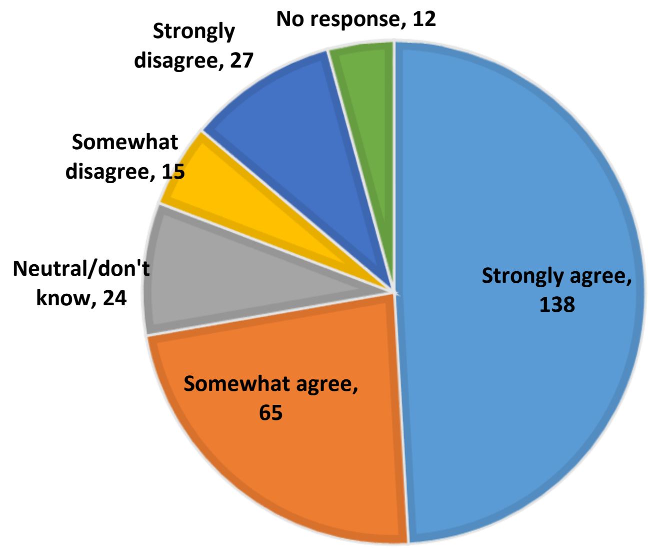

Figure 5.9: Use of mobile technologies as substitutes for desktop computers

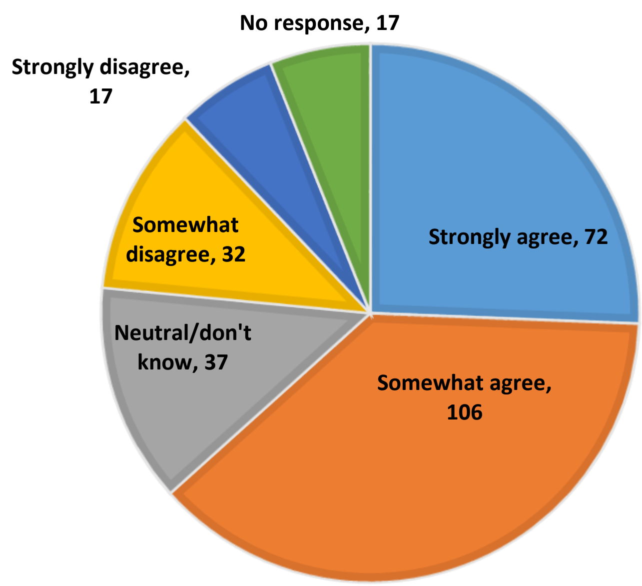

Figure 5.10: Use of mobile technologies as substitutes for laptop computers

Table 5.3 summarizes the number of students that owned various mobile devices. Only one student indicated not owning a mobile device. Laptop computer was the most owned device, followed by smartphone, cellular phone and tablet computer, in order of decreasing frequency. In terms of the number of mobile devices owned, most students (69.4%) owned either two or three devices (Figure 5.11).

Table 5.3: Mobile devices owned by students

Mobile device	Number of students
None	1 (0.4%)
Laptop computer	255 (90.8%)
Tablet computer	124 (44.1%)
Cellular phone	131 (46.6%)
iPod (or similar device)	62 (22.1%)
Smartphone	186 (66.2%)
Smartwatch	13 (4.6%)
Smart wristband (including wearable pulse oximeter)	4 (1.4%)
Smartphone/wireless/wearable stethoscope	26 (9.3%)
Smartphone/wireless/wearable ultrasound device	1 (0.4%)
Smartphone/wireless/wearable electrocardiography (ECG) monitor	1 (0.4%)
Smartphone/wireless/wearable electroencephalography (EEG) monitors,	1 (0.4%)
Smartphone/wireless otoscope	8 (2.9%)
Others	2 (0.7%)

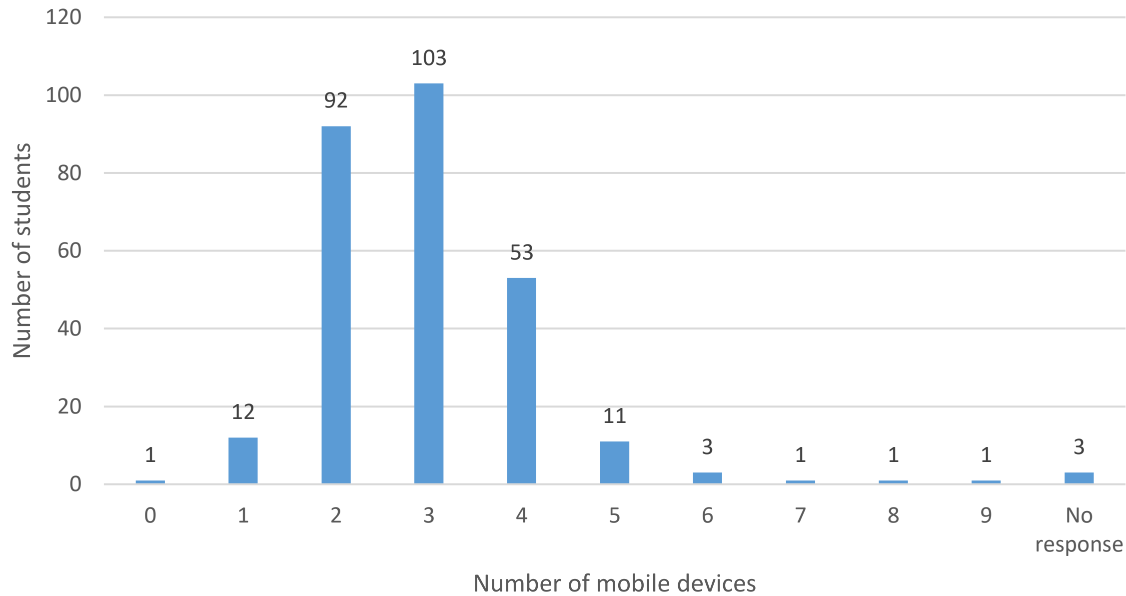

Figure 5.11: Number of mobile devices owned by students

From Table 5.4, it is evident that Android, Windows and iOS were the three most common operating systems running mobile devices owned by students, recording percentages of 84.7%, 39.9% and 21.4% respectively. The data appear to show a gross under-reporting of laptop operating systems. A total of 255 students reported owning laptops, however, the total number of students reporting operating systems that typically run laptops (Windows, MacOS, Chrome OS and Linux) was only 141.

Table 5.4: Operating systems that run on students' mobile devices

Operating system	Number of students
No access to mobile technology	2 (0.7%)
Apple iOS	60 (21.4%)
Apple MacOS	13 (4.6%)
Android	238 (84.7%)
Blackberry OS	1 (0.4%)
Chrome OS	11 (3.9%)
Linux OS (e.g. Ubuntu, Elementary OS, Mint, Gentoo, Snappy, Slax)	1 (0.4%)
Microsoft Windows	112 (39.9%)
Microsoft Windows Mobile	11 (3.9%)
Microsoft Windows Phone	15 (5.3%)
Other	1 (0.4%)

From Table 5.5, Android was the most frequently used operating system. Although the question required students to choose only one option, the data show that this was not easy for them to do, as many of them selected more than one option. This is probably evidence of a growing trend where people use multiple devices simultaneously. Choices that were grouped as "Others" had frequencies of 1 or 2 and are as follows: iOS & MacOS; iOS (2), MacOS & Android (1); iOS, Android & Windows (1); Android & Chrome OS (1); Android & Windows Mobile/Phone (1); Blackberry OS (1); and Windows & Windows Mobile/Phone (3).

Table 5.5: Most frequently used operating systems

Operating system	Number of students
Android	199 (70.1%)
Android & Windows	10 (3.6%)
Windows	14 (5.0%)
Windows Mobile/Phone	6 (2.14%)
Apple iOS	32 (11.4%)
Apple iOS & Windows	4 (1.4%)
Apple MacOS	3 (1.1%)
Others	10 (3.6%)
No response	3 (1.1%)

Most students accessed the internet through their personal data plans and/or Wi-Fi services provided by their schools (Table 5.6). Personal data plan usage was twice as reported as use of school Wi-Fi. One student indicated using an internet café to access the internet.

Table 5.6: Ways of accessing internet for mobile devices

Internet source	Number of students
I do not use the internet	2 (0.7%)
School WI-FI	130 (46.3%)
Other WI-FI	28 (10.0%)
Personal data plan/package	278 (98.9%)
Other	1 (0.4%)

Personal data plans were the most frequently used sources of internet (Table 5.7). Five students gave invalid responses for the most frequently used internet sources on mobile devices. These respondents selected more than one option on paper questionnaires, despite instructions to select only option. One student selected School WI-FI, Other WI-FI and Personal data plan/package as the most frequently used sources of internet. The four remaining students selected School WI-FI and Personal data plan/package.

Table 5.7: Most frequently used source of internet on mobile devices

Internet source	Number of students
I do not use the internet	1 (0.4%)
School WI-FI	5 (1.8)
Other WI-FI	0 (0%)
Personal data plan/package	267 (95.0%)
Other	0 (0%)
Invalid responses	5 (1.8%)
No response	3 (1.1%)

About 35% of the students, spent GHS10.00 – GHS19.99 (approximately CAD 2.70 – CAD 5.40) on a personal data plan/package per month for their mobile devices. This was the modal data plan. Depending on which mobile network one was using, this amount would provide 300Mb – 1.5Gb of data per month. The median data plan was GHS20.00 – GHS29.99 (CAD5.40 – CAD8.10) per month. Table 5.8 provides a break down of how much students spent on personal data packages per month.

Table 5.8: Estimated monthly cost of using a personal data plan/package

Estimated cost	Number of students	Monthly data quota[1]
None	0 (0%)	-
<GHS 3.00	1 (0.4%)	<100MB
GHS 3.00 – GHS 9.99	9 (3.2%)	100 – 300MB
GHS 10.00 – GHS 19.99	97 (34.5%)	300MB – 1.5GB
GHS 20.00 – GHS29.99	58 (20.6%)	1 – 2GB
GHS 30.00 – GHS 39.99	40 (14.2%)	2 – 3GB
GHS 40.00 – GHS 49.99	22 (7.8%)	2.5 – 4GB
≥ GHS 50.00	44 (15.7%)	>4GB
Prefer not to answer	5 (1.8%)	-
No response	5 (1.8%)	-

[1]Sources: Airtel Ghana (n.d.); Globacom Limited (n.d.); MTN Ghana (n.d.); Vodafone Ghana (n.d.)

5.1.2.2 Uses of m-health and the contexts in which they are used

Majority of students (78%) reported having used m-health while in medical or dental school (Figure 5.12). Five (5) students did not respond to the question asking if they had used m-health while in medical or dental school.

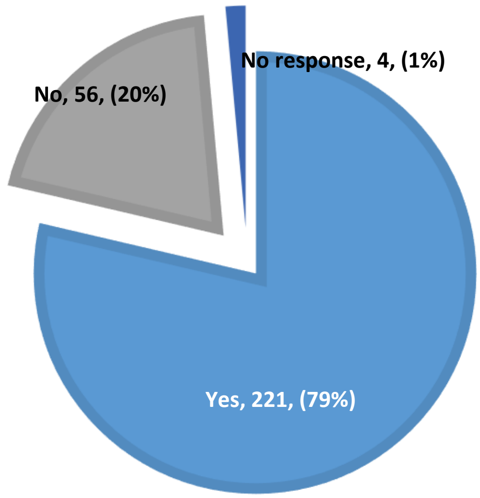

Figure 5.12: M-health use status

Out of 221 students who reported using m-health, 218 provided information regarding how long they had been using m-health. Majority of them (69.7%) reported using m-health for three or more years (Table 5.9). In terms of proportions, second and third clinical year students appeared to have similar lengths of time using m-health. However, a smaller proportion of first clinical year students had used m-health for three or more years compared to second and third clinical year students.

Table 5.9: Self-reported length of time of m-health use (experience)

	Clinical year			
Time	**First**	**Second**	**Third**	**Total**
≤ 1 year	7 (8.8%)	1 (1.0%)	1 (2.4%)	9 (4.1%)
1 – 2 years	11 (13.8%)	11 (11.0%)	3 (7.3%)	25 (11.3%)
2 – 3 years	14 (17.5%)	11 (11.0%)	5 (12.2%)	30 (13.6%)
≥ 3 years	46 (57.5%)	77 (77.0%)	31 (75.6%)	154 (69.7%)
No response	2 (2.5%)	0 (0%)	1 (2.4%)	3 (1.4%)
Total	80	100	41	221

Out of 221 students who reported using m-health, majority of them learned about new m-health platforms and technologies through colleagues/peers (78.4%) and on the internet (70.5%). One student indicated learning about m-health from a family member. About 40% of students reported learning about new technologies from their instructors, teachers or faculty members (Table 5.10).

Table 5.10: How students learn about new m-health technologies

Source	Number of students
Colleagues/peers	175 (79.2%)
Tutors/teachers/faculty members	88 (39.8%)
School administration	5 (2.3%)
Non-academic staff	30 (13.6%)
Online	156 (70.6%)
Other	4 (1.8%)

Students tended to use m-health less frequently in the classroom and during clinical sessions (Table 5.11). Out of 221 students who reported using m-health, the modal response for m-health use in the classroom was “sometimes” (47.1%). Students who used m-health in the classroom “about half the time,” “most of the time” and “always” represented 17.7%, 22.2% and 7.2% of respondents respectively. This trend was quite similar when it came to m-health use during clinical sessions or patient care. Majority of students used m-health “sometimes” or “about half the time. The median frequency of use in the classroom and during clinical sessions was “about half the time.”

During individual or group studies, however, the trend was different (Table 20). Majority of students used m-health “most of the time” or “always.” Over 36% of students reported using m-health “most of the time,” while about 23% said they used it “always.” The median frequency of m-health use in this context was “most of the time,”

Table 5.11: Frequency of m-health use in different contexts

Context	Never	Sometimes	About half the time	Most of the time	Always	No response
Classroom	5 (2.3%)	104 (47.1%)	39 (17.7%)	49 (22.2%)	16 (7.2%)	8 (3.6%)
Individual or group studies	7 (3.2%)	37 (16.7%)	39 (17.7%)	81 (36.7%)	51 (23.1%)	6 (2.7%)
Clinical sessions or patient care	27 (4.1%)	248 (37.4%)	123 (18.6%)	157 (23.7%)	84 (12.7%)	24 (3.6%)

In general, apps and websites were used in the medical decision-making process—diagnosing conditions, choosing the right medications and determining the right dosages. Medicines formularies used by students included British National Formulary (BNF), DailyRounds app, Epocrates app and Medscape (Table 5.12). The most popular standard treatment guidelines (STG) were the Ghana Standard Treatment Guidelines, which are available in the PDF format and as a free app. Other STGs listed by students were Oxford Medical Dictionary, WHO Standard Treatment Guidelines and Medscape. Nine (9) students provided information about other functions, apps or programs they used. Apps and websites included Medscape, BMI, WebMD, Cancer Staging, GCS, Mayo Clinic, Wikipedia, Drugs.com and an anatomy app. One student indicated visiting online medical forums, which would most likely be performed using a web browser or social media app. Another student indicated solving past exam questions, although there was no information detailing whether this was done using an app or web browser. The modal frequency of using web browsers was “always” while that for phone calling and SMS messaging was “never.” One student indicated having Medscape and Oxford Medical Dictionary apps but never used them.

Table 5.12: Frequency of using various m-health functions, apps or programs

Function, app or program	Never	Sometimes	About half the time	Most of the time	Always	No response
Phone calling	72 (32.6%)	59 (26.7%)	26 (11.8%)	29 (13.1%)	25 (11.3%)	10 (4.5%)
Short message service (SMS)	77 (34.8%)	70 (31.7%)	24 (10.9%)	20 (9.1%)	15 (6.8%)	15 (6.8%)
Photo gallery or similar app/program	24 (10.9%)	72 (32.6%)	47 (21.3%)	46 (20.8%)	20 (9.1%)	12 (5.4%)
Video player/streaming	33 (14.9%)	67 (30.3%)	46 (20.8%)	41 (18.6%)	22 (10.0%)	12 (5.4%)
Web browser	7 (3.2%)	32 (14.5%)	26 (11.8%)	68 (30.8%)	72 (32.6%)	16 (7.2%)
Medicines formulary	52 (23.5%)	52 (23.5%)	33 (14.9%)	29 (13.1%)	13 (5.9%)	42 (19.0%)
Standard treatment guidelines	47 (21.3%)	58 (26.2%)	35 (15.8%)	28 (12.7%)	12 (5.4%)	41 (18.6%)

Students used laptop computers “most of the time” (29.9%) or “always” (29.0%), while that for tablet computers was “never” (30.3%) or “sometimes” (24.0%). The modal frequency of using cellular phones and smartphones was “always” (34.4%) while that for iPods or similar devices was “never” (52.5%). Since many smartphones can perform the same functions as iPods and similar media playing devices, it is not surprising that students in this survey did not use iPods or similar devices frequently. Newer innovations such as smart/wireless watches, wristbands, stethoscopes, ultrasound scanners, ECG, EEC and otoscopes had modal use frequencies of “never.”

Table 5.13: Frequency of device usage

Device	Never	Sometimes	About half the time	Most of the time	Always	No response
Laptop computer	9 (4.1%)	43 (19.5%)	36 (16.3%)	66 (29.9%)	64 (29.0%)	3 (1.4%)
Tablet computer	67 (30.3%)	53 (24.0%)	29 (13.1%)	26 (11.8%)	30 (13.6%)	16 (7.2%)
Cellular phone	47 (21.3%)	32 (14.5%)	15 (6.8%)	30 (13.6%)	76 (34.4%)	21 (9.5%)
iPod (or similar device)	116 (52.5%)	14 (6.3%)	8 (3.6%)	15 (6.8%)	23 (10.4%)	45 (20.4%)
Smartphone	44 (19.9%)	15 (6.8%)	9 (4.1%)	40 (18.1%)	88 (39.8%)	25 (11.3%)
Smart watch	153 (69.2%)	9 (4.1%)	5 (2.3%)	0 (0%)	4 (1.8%)	50 (22.6%)
Smart wristband (including wearable pulse oximeter)	159 (72.0%)	4 (1.8%)	4 (1.8%)	0 (0%)	4 (1.8%)	50 (22.6%)
Smartphone/wireless/wearable stethoscope	141 (63.8%)	7 (3.2%)	12 (5.4%)	12 (5.4%)	5 (2.3%)	44 (19.9%)
Smartphone/wireless/wearable ultrasound device	159 (71.9%)	3 (1.4%)	5 (2.3%)	0 (0%)	3 (1.4%)	51 (23.1%)
Smartphone/wireless/wearable electrocardiography (ECG) monitor	161 (72.9%)	3 (1.4%)	4 (1.8%)	0 (0%)	4 (1.8%)	49 (22.2%)
Smartphone/wireless/wearable electroencephalography (EEG) monitors	164 (74.2%)	1 (0.5%)	3 (1.4%)	0 (0%)	3 (1.4%)	50 (22.6%)
Smartphone/wireless otoscope	139 (62.9%)	15 (6.8%)	4 (1.8)	3 (1.4%)	3 (1.4%)	57 (25.8%)

For students that self-reported as being users of m-health (N=221), the most common school-related activities performed using mobile technology were communicating with colleagues (65.2%) and accessing social media including media sharing websites (57.0%). Table 5.14 summarizes school-related activities performed using m-health technology.

Table 5.14: School-related activities performed using m-health technology

Activity	Number of students
Access OER materials from my tutors	53 (24.0%)
Access OER materials from other universities	39 (17.7%)
Access Free Open Access 'Meducation' (FOAM) resources	39 (17.7%)
Access MEDSKL resources	24 (10.9%)
Access calendar or “to do” lists or improve timetabling	59 (26.7%)
Communicate with colleagues	144 (65.2%)
Communicate patient information with colleagues or patients	51 (23.1%)
Communicate with tutors	62 (28.1%)
Communicate with patients/carers	33 (14.9%)
Access social media including media sharing websites	126 (57.0%)

Within the educational environment, the most frequently reported social media activity was accessing up-to-date school-related information (65.2%) (Table 5.15). This was followed closely by exchanging academically relevant ideas with colleagues or practitioners and accessing information about the latest trends in medicine/dentistry, each recording frequencies of 61.1% respectively. About 60% of m-health users used social media to pursue hobbies and extracurricular activities. Almost half of m-health users reported using social media to make new friends or connect with old friends while within the educational environment. Eight (3.6%) students indicated that they used social media for activities other than those that were listed. These included accessing information about scholarships, following medical groups that post cases for discussion, obtaining quick confirmation of information, extra reading and for ideas when doing assignments.

Table 5.15: Uses of social media within the educational environment

Activity	Number of students (N=220)
I do not use social media	2 (0.9%)
Make new friends or connect with old friends	109 (49.3%)
Pursue hobbies and extra-curricular interests	133 (60.2%)
Access up-to-date school-related information e.g. events, schedules, etc.	144 (65.2%)
Exchange academically relevant ideas with colleagues or practitioners	135 (61.1%)
Access information about the latest trends in medicine/dentistry	135 (61.1%)
Others	8 (3.6%)

In terms of content, most students used their technologies for accessing images (87.8%) and videos (81.5%) (Table 5.16). Indexed or searchable text information was also accessed by majority of students (74.2%). Podcasts and other audio, and simulations, games and role-play were not widely used forms of content.

Table 5.16: Types of content accessed via m-health

Content	Number of students (N=220)
Indexed or searchable text	164 (74.2%)
Images	194 (87.8%)
Podcasts and other audio	40 (18.1%)
Videos	180 (81.5%)
Simulations, games or role-play	57 (25.8%)

5.1.3 Impact of m-health (benefits and drawbacks)

Table 5.17 provides descriptive statistics for measurement indicators for the variable Performance Expectancy, from the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). Over 80% of students strongly agreed/somewhat agreed that m-health was useful in their school lives, helped them accomplish things more quickly and helped increase their productivity.

Table 5.17: UTAUT2 measurement indicators for Performance Expectancy

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
PE1. I find m-health technology useful in my school life.	153 (69.2%)	40 (18.1%)	5 (2.3%)	8 (3.6%)	7 (3.2%)	8 (3.6%)
PE3. Using m-health technology helps me accomplish things more quickly.	141 (63.8%)	49 (22.2%)	7 (3.2%)	8 (3.6%)	7 (3.2%)	9 (4.1%)
PE4. Using m-health technology increases my productivity.	127 (57.5%)	59 (26.7%)	8 (3.6%)	11 (5.0%)	6 (2.7%)	10 (4.5%)

For the UTAUT2 variable Effort Expectancy, majority of students strongly agreed/somewhat agreed that learning to use m-health was easy, their interaction with m-health was clear and understandable, they found m-health easy to use and felt it was easy to become skilled at using m-health technology (Table 5.18).

Table 5.18: UTAUT2 measurement indicators for Effort Expectancy

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
EE1. Learning how to use m-health technology is easy for me	81 (36.7%)	85 (38.5%)	28 (12.7%)	12 (5.4%)	7 (3.2%)	8 (3.6%)
EE2. My interaction with m-health technology is clear and understandable	80 (36.2%)	85 (38.5%)	29 (13.1%)	11 (5.0%)	6 (2.7%)	10 (4.5%)
EE3. I find m-health technology easy to use	87 (39.4%)	92 (41.6%)	17 (7.7%)	11 (5.0%)	6 (2.7%)	8 (3.6%)
EE4. It is easy for me to become skillful at using m-health technology.	73 (33.0%)	100 (45.3%)	23 (10.4%)	10 (4.5%)	7 (3.2%)	8 (3.6%)

Table 5.19 summarizes students' responses to listed benefits of m-health use. With the exception of staying engaged in class or by the patient side, majority of the students strongly or somewhat agreed that m-health enabled or motivated them to attain all the listed benefits. For staying more engaged in class or by the patient side, although the largest proportion of the students (45.2%) strongly or somewhat agreed that m-health enabled or motivated them to attain that, 31.7% selected the "neutral/don't know" response. This is most likely because the mobile technology is distractive/disruptive in those settings. Table 5.20 provides further information on students' perceptions about the distractive/disruptive nature of m-health.

Table 5.19: Benefits of m-health use

Benefit	Strongly Agree	Somewhat Agree	Neutral/ don't know	Somewhat disagree	Strongly disagree	No response
Stay more engaged in class or by the patient side	37 (16.7%)	63 (28.5%)	70 (31.7%)	32 (14.5%)	6 (2.7%)	13 (5.9%)
Access ideas, concepts and new knowledge	136 (61.5%)	55 (24.9%)	10 (4.5%)	6 (2.7%)	5 (2.3%)	9 (4.1%)
Improve my basic science knowledge and skills	126 (57.0%)	67 (30.3%)	6 (2.7%)	5 (2.3%)	7 (3.2%)	10 (4.5%)
Improve my clinical knowledge and skills	124 (56.1%)	65 (29.4%)	10 (4.5%)	5 (2.3%)	7 (3.2%)	10 (4.5%)
Confirm information I already knew	136 (61.5%)	51 (23.1%)	13 (5.9%)	4 (1.8%)	7 (3.2%0	10 (4.5%)
Ask questions of the teacher or my peers	66 (29.9%)	70 (31.7%)	49 (22.2%)	15 (6.8%)	6 (2.7%)	15 (6.8%)
Offer my ideas to the teacher or my peers	65 (29.4%0	75 (33.9%)	43 (19.5%)	16 (7.2%)	8 (3.6%)	14 (6.3%)
Discuss and debate my ideas with other learners	77 (34.8%)	79 (35.8%)	32 (14.5%)	14 (6.3%)	6 (2.7%)	13 (5.9%)
Apply what I have learned to clinical practice	89 (40.3%)	74 (33.5%)	28 (12.7%)	9 (4.1%)	4 (1.8%)	17 (7.7%)
Repeatedly practice what I've learned, using feedback	62 (28.1%)	71 (32.1%)	52 (23.5%)	17 (7.7%)	4 (1.8%)	15 (6.8%)

Benefit	Strongly Agree	Somewhat Agree	Neutral/ don't know	Somewhat disagree	Strongly disagree	No response
that enables me to improve performance						
Share my practice outputs with peers, for comparison and comment	57 (25.8%)	80 (36.2%)	47 (21.3%)	19 (8.6%)	3 (1.4%)	15 (6.8%)
Reflect on my learning experience, by presenting my own ideas, reports, designs (productions) to peers	59 (26.7%)	68 (30.8%)	55 (24.9%)	19 (8.6%)	1 (0.5%)	19 (8.6%)
Improve my learning experience	124 (56.1%)	66 (29.9%)	8 (3.6%)	4 (1.8%)	5 (2.3%)	14 (6.3%)
Improve efficiency in the clinical environment	98 (44.3%)	73 (33.0%)	21 (9.5%)	7 (3.2%)	4 (1.8%)	18 (8.1%)
Improve patient care	59 (26.7%)	70 (31.7%)	33 (14.9%)	6 (2.7%)	4 (1.8%)	49 (22.2%)

In general, more students strongly agreed or somewhat agreed that m-health was distracting/disruptive in the classroom, during individual/group studies or during clinical practice compared to those who strongly disagreed or somewhat disagreed (Table 5.20). One hundred and twenty-eight students (58%) strongly or somewhat agreed that m-health was distracting/disruptive when used in the classroom. Almost the same proportions of m-health users strongly agreed or somewhat agreed (40.3%) compared somewhat disagreed/strongly disagreed (39.4%) that m-health was distracting/disruptive during individual/group studies. When it came to m-health being distracting/disruptive during clinical practice, 46.2% of respondents strongly or somewhat agreed that it was.

About 55.7% of the students either strongly disagreed or somewhat disagreed that the use of m-health demotivates knowledge retention. Similarly, about 53.4% of the students either strongly disagreed or somewhat disagreed that m-health demotivates skill retention.

Table 5.20: Drawbacks of m-health reported by m-health users

M-health drawback	Strongly Agree	Somewhat Agree	Neutral/ don't know	Somewhat disagree	Strongly disagree	No response
Is distracting/disruptive in the classroom	39 (17.7%)	89 (40.3%)	28 (12.7%)	37 (16.7%)	15 (6.8%)	13 (5.9%)
Is distracting/disruptive during individual or group studies	17 (7.7%)	72 (32.6%)	30 (13.6%)	63 (28.5%)	24 (10.9%)	15 (6.8%)
Is distracting/disruptive during clinical practice	22 (10.0%)	80 (36.2%)	28 (12.7%)	54 (24.4%)	22 (10.0%)	15 (6.8%)
Demotivates knowledge retention	19 (8.6%)	34 (15.4%)	31 (14.0%)	59 (26.7%)	64 (29.0%)	14 (6.3%)
Demotivates skill retention	15 (6.8%)	31 (14.0%)	38 (17.2%)	58 (26.2%)	60 (27.2%)	19 (8.6%)

5.1.4 Facilitating conditions (enablers and barriers) of m-health use

This section presents findings about conditions that facilitate m-health use. It consists of summaries of measurement indicators for four UTAUT2 variables, namely, Facilitating Conditions, Price Value, Social Influence and Hedonic Motivation. In addition to these indicators, this study examined other facilitating conditions collectively framed as enablers and barriers later in this section. There is also further probing into sources of technical support when students encounter problems with their m-health technologies

For the UTAUT2 variable Facilitating Conditions, majority of students strongly agreed or somewhat agreed with each of the measurement indicators (Table 5.21).

Table 5.21: UTAUT2 measurement indicators for Facilitating Conditions

Indicator	Strongly Agree	Somewhat Agree	Neutral/ don't know	Somewhat disagree	Strongly disagree	No response
FC1. I have the resources necessary to use m-health technology.	41 (18.6%)	93 (42.1%)	29 (13.1%)	27 (12.2%)	10 (4.5%)	21 (9.5%)
FC2. I have the knowledge necessary to use m-health technology.	49 (22.2%)	92 (41.6%)	32 (14.5%)	21 (9.5%)	3 (1.4%)	24 (10.9%)
FC3. M-health technology is compatible with other technologies I use.	52 (23.5%)	98 (44.3%)	36 (16.3%)	9 (4.1%)	3 (1.4%)	23 (10.4%)
FC4. I can get help from others when I have difficulties using m-health technology.	75 (33.9%)	90 (40.7%)	18 (8.1%)	10 (4.5%)	2 (0.9%)	26 (11.8%)

In terms of how reasonably priced m-health technology was for students, the responses were varied with almost the same percentage somewhat agreeing, neutral or somewhat disagreeing that m-health technology is reasonably priced. In terms of being fair value for money, 37.6% of the students strongly agreed or somewhat agreed that it was, representing the largest proportion of responses for that question. However, in terms of providing fair value at the current price, the modal response was "neutral/don't know" representing 35.8% of responses. This exceeded the proportion of students who strongly agreed or somewhat agreed (33.1%).

Table 5.22: UTAUT2 measurement indicators for Price Value

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
PV1. M-health technology is reasonably priced.	24 (10.9%)	52 (23.5%)	55 (24.9%)	56 (25.3%)	9 (4.1%)	25 (11.3%)
PV2. M-health technology is a fair value for the money.	21 (9.5%)	62 (28.1%)	73 (33.0%)	30 (13.6%)	6 (2.7%)	29 (13.1%)
PV3. At the current price, m-health technology provides a fair value.	20 (9.1%)	53 (24.0%)	79 (35.8%)	32 (14.5%)	11 (5.0%)	26 (11.8%)

M-health use can be encouraged or restrained by perceptions, expectations and attitudes of significant social connections. In the study setting, students' significant social connections would be their colleagues, instructors, patients and carers. Although the modal response to each of the statements in Table 5.23 is "neutral/don't know" (percentages ranged from 31.2% to 33%), a much larger percentage strongly agreed or somewhat agreed with each statement (percentages ranged from 47.1% to 50.7%).

Table 5.23: UTAUT2 measurement indicators for Social Influence

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
SI1. People who are important to me (e.g. tutors, colleagues, patients, carers) think that I should use m-health technology.	43 (19.5%)	69 (31.2%)	73 (33.0%)	10 (4.5%)	2 (0.9%)	24 (10.9%)
SI2. People who influence my behavior think that I should use m-health technology.	41 (18.6%)	69 (31.2%)	69 (31.2%)	11 (5.0%)	4 (1.8%)	27 (12.2%)
SI3. People whose opinions that I value prefer that I use m-health technology.	40 (18.1%)	64 (29.0%)	72 (32.6%)	14 (6.3%)	2 (0.9%)	29 (13.1%)

The fun and pleasure associated with m-health use can motivate students to continue using those technologies. Majority of students (62% to 69.7%) strongly agreed or somewhat agreed that using m-health was fun, enjoyable and entertaining (Table 5.24).

Table 5.24: UTAUT2 measurement indicators for Hedonic Motivation

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
HM1. Using m-health technology is fun	82 (37.1%)	70 (31.7%)	37 (16.7%)	3 (1.4%)	3 (1.4%)	26 (11.8%)
HM2. Using m-health technology is enjoyable	81 (36.7%)	73 (33.0%)	34 (15.4%)	4 (1.8%)	3 (1.4%)	26 (11.8%)
HM3. Using m-health technology is very entertaining	76 (34.4%)	61 (27.6%)	48 (21.7%)	7 (3.2%)	3 (1.4%)	26 (11.8%)

Assessment of enablers and barriers to m-health use was conducted for all students—both m-health users and non-users (N=281) (Table 5.25). The first striking thing in Table 5.25 was the relatively large number of non-responses compared to other tables in this section, ranging from 16.7% to 51.3%. Also, for most statements, there was hardly a dominant response. However, for some statements, the percentage of students who strongly agreed or somewhat agreed was greater than the percentage of students who strongly disagreed or somewhat disagreed. These included statements that m-health use was enabled or enhanced because internet service was reliable (34.1%) and power was adequate for students' m-health needs (34.6%). Furthermore, a greater percentage of students strongly agreed or somewhat agreed that their m-health use was constrained or limited because they had difficulty viewing content on a small screen (40.9%), got distracted (34.5%), were unsure of tutors'/clinicians' reactions (39.6%) or were unsure of patients'/carers' reactions (33.1%). On the other hand, for four statements, the greater percentage of students strongly disagreed or somewhat disagreed, for example, 37.7% of the students strongly disagreed or somewhat disagreed that their m-health use was enhanced or encouraged because internet speed was adequate for their needs.

Table 5.25: Enablers and barriers of m-health use

Enablers	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
M-health use is enabled or enhanced because:						
Internet service is reliable	22 (7.8%)	74 (26.3%)	46 (16.4%)	67 (23.8%)	25 (8.9%)	47 (16.7%)
Internet speed is adequate for my needs	20 (7.1%)	59 (21.0%)	46 (16.4%)	73 (26.0%)	33 (11.7%)	50 (17.8%)
Power supply is adequate for my m-health needs	19 (6.8%)	78 (27.8%)	47 (16.7%)	57 (20.3%)	28 (10.0%)	52 (18.5%)
M-health use is constrained or limited because:						
I have difficulty viewing content on a small screen	49 (17.4%)	66 (23.5%)	40 (14.2%)	55 (19.6%)	24 (8.5%)	47 (16.7%)
I get distracted	29 (10.3%)	68 (24.2%)	63 (22.4%)	51 (18.2%)	20 (7.1%)	50 (17.8%)
I am unsure of tutors'/clinicians' reactions	26 (9.3%)	85 (30.3%)	80 (28.5%)	29 (10.3%)	11 (3.9%)	50 (17.8%)
I am unsure of patients'/carers' reactions	28 (10.0%)	65 (23.1%)	84 (29.9%)	36 (12.8%)	15 (5.3%)	53 (18.9%)
I have multiple devices	32 (11.4%)	53 (18.9%)	47 (16.7%)	59 (21.0%)	39 (13.9%)	51 (18.2%)
Mobile learning is not my preferred learning style	18 (6.4%)	40 (14.2%)	32 (11.4%)	86 (30.6%)	54 (19.2%)	51 (18.2%)
I have lost/fear losing my device	31 (11.0%)	47 (16.7%)	50 (17.8%)	58 (20.6%)	42 (15.0%)	53 (18.9%)
I am unsure about legal implications or consequences	22 (7.8%)	36 (12.8%)	49 (17.4%)	28 (10.0%)	14 (5.0%)	132 (47.0%)
I have limited awareness about m-health	24 (8.5%)	27 (9.6%)	25 (8.9%)	34 (12.1%)	27 (9.6%)	144 (51.3%)

Students tended to seek help from their colleagues when they encountered problems using m-health. About 78% of students strongly agreed or somewhat agreed that they sought assistance from colleagues/peers when they encountered technical problems. Students also tried to troubleshoot problems by themselves. About 58% of students strongly agreed or somewhat agreed that they used self-help. About 50.7% and 48.4% strongly disagreed or somewhat disagreed that they seek technical assistance from institutional IT support staff and external/commercial IT services respectively. Table 5.26 summarizes these findings.

Table 5.26: Sources of technical support when students encounter problems with m-health

Source of technical support	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
Myself	59 (26.7%)	70 (31.7%)	19 (8.6%)	33 (14.9%)	14 (6.3%)	26 (11.8%)
Institutional IT support staff	22 (10.0%)	31 (14.0%)	28 (12.7%)	52 (23.5%)	60 (27.2%)	28 (12.7%)
Colleagues/peers	99 (44.8%)	74 (33.5%)	14 (6.3%)	9 (4.1%)	4 (1.8%)	21 (9.5%)
Family members	26 (11.8%)	56 (25.3%)	28 (12.7%)	43 (19.5%)	41 (18.6%)	27 (12.2%)
External/commercial IT services	27 (12.2%)	33 (14.9%)	23 (10.4%)	48 (21.7%)	59 (26.7%)	31 (14.0%)

5.1.5 Attitudes towards m-health use

Majority of students felt that using m-health had become a habit for them (Table 5.27). Fifty-eight students (26.2%) strongly agreed, while 90 students (40.7%) somewhat agreed that m-health had become a habit for them. However, a larger percentage of students strongly disagreed or somewhat disagreed (38%) than those who strongly agreed or somewhat agreed (32.5%) to being addicted to m-health. Nonetheless, a large proportion of students felt that they must use m-health technology, as shown by 47.5% who strongly agreed or somewhat agreed. Majority of students felt that using m-health had become natural to them, as shown by 63.4% of respondents who strongly agreed or somewhat agreed.

Table 5.27: UTAUT2 measurement indicators for Habit

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
HT1. The use of m-health technology has become a habit for me.	58 (26.2%)	90 (40.7%)	30 (13.6%)	23 (10.4%)	6 (2.7%)	14 (6.3%)
HT2. I am addicted to using m-health technology.	18 (8.1%)	54 (24.4%)	50 (22.6%)	63 (28.5%)	21 (9.5%)	15 (6.8%)
HT3. I must use m-health technology.	27 (12.2%)	78 (35.3%)	43 (19.5%)	39 (17.7%)	18 (8.1%)	16 (7.2%)
HT4. Using m-health technology has become natural to me.	45 (20.4%)	98 (43.0%)	36 (16.3%)	19 (8.6%)	9 (4.1%)	17 (7.7%)

Concern about other students using m-health in the classroom was not clear-cut (Table 5.28). The modal and median responses were "neutral/don't know" and this represents 29% of responses. More students somewhat disagreed or strongly disagreed (25.2%) that they had concerns about other students using m-health in the classroom compared to those who strongly agreed or somewhat agreed (19.9%). On the other hand, students tended to somewhat disagree or strongly disagree with having concerns about other students using m-health during individual or group studies, and during patient care, representing 46.1% and 40.3% of responses respectively.

Table 5.28: Attitudes about other students using m-health

Attitude	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
I have concerns about other students using m-health in the classroom	14 (6.3%)	30 (13.6%)	64 (29.0%)	33 (14.9%)	25 (11.3%)	55 (24.9%)
I have concerns about other students using m-health for individual or group studies	7 (3.2%)	14 (6.3%)	43 (19.5%)	48 (21.7%)	54 (24.4%)	55 (24.9%)
I have concerns about other students using m-health for patient care	12 (5.4%)	17 (7.7%)	47 (21.3%)	48 (21.7%)	41 (18.6%)	56 (25.3%)

Majority of existing m-health users expressed the intention to continue using m-health in future. Modal responses to each of the statements in Table 5.29 was "strongly agree," with response rates ranging from 41.6% to 45.7%. The median response for each statement was also "strongly agree." Students strongly agreed or somewhat agreed to use m-health in future (71.9%) in school life (69.2%), frequently (69.7%), when introduced into the school curriculum (67.9%) and if they encounter it in the work setting (66.5%) (Table 5.29). Non-response rates for statements in this table ranged from 24.4% to 24.9%.

Table 5.29: UTAUT2 measurement indicators for Behavioral Intention to use m-health in future

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
BI1. I intend to continue using m-health technology in the future.	92 (41.6%)	67 (30.3%)	5 (2.3%)	2 (0.9%)	1 (0.5%)	54 (24.4%)
BI2. I will always try to use m-health technology in my school life.	98 (44.3%)	55 (24.9%)	11 (5.0%)	1 (0.5%)	2 (0.9%)	54 (24.4%)
BI3. I plan to continue to use m-health technology frequently.	93 (42.1%)	61 (27.6%)	9 (4.1%)	3 (1.4%)	1 (0.5%)	54 (24.4%)
BI41. I will use m-health if introduced in the school curriculum	101 (45.7%)	49 (22.2%)	8 (3.6%)	4 (1.8%)	4 (1.8%)	55 (24.9%)
BI5. I will use m-health for patient care if I encounter it in the work setting.	95 (43.0%)	52 (23.5%)	14 (6.3%)	3 (1.4%)	3 (1.4%)	54 (24.4%)

Behavioral intention for non-m-health users was not as strong as those of m-health users (see Table 5.30). With the exception of continuing to use m-health frequently, which had a modal response of "neutral/don't know" (37.5%) each statement had a modal response of "somewhat agree." It appears that among this subgroup of respondents, a major driving factor to their intention to use m-health will be its introduction into the curriculum, with 75% of respondents strongly agreeing or somewhat agreeing to use m-health if introduced into their school curricula.

Table 5.30: Non-user students' behavioral intention towards m-health use in future

Indicator	Strongly Agree	Somewhat Agree	Neutral /don't know	Somewhat disagree	Strongly disagree	No response
BI1. I intend to continue using m-health technology in the future.	9 (16.1%)	19 (33.9%)	18 (32.1%)	3 (5.4%)	1 (1.8%)	6 (10.7%)
BI2. I will always try to use m-health technology in my school life.	7 (12.5%)	20 (35.7%)	19 (33.9%)	1 (1.8%)	2 (3.6%)	7 (12.5%)
BI3. I plan to continue to use m-health technology frequently.	6 (10.7%)	19 (33.9%)	21 (37.5%)	2 (3.6%)	1 (1.8%)	7 (12.5%)
BI41. I will use m-health if introduced in the school curriculum	14 (25.0%)	28 (50.0%)	6 (10.7%)	1 (1.8%)	1 (1.8%)	6 (10.7%)
BI5. I will use m-health for patient care if I encounter it in the work setting.	15 (26.8%)	22 (39.3%)	9 (16.1%)	2 (3.6%)	1 (1.8%)	7 (12.5%)

5.2 Hypothesis testing I

For this section of hypothesis testing, there are two dependent variables, namely, (1) m-health use status and (2) frequency of m-health use. M-health use status is a nominal variable with a binary outcome: yes or no. Frequency of m-health use is an ordinal variable with five levels, namely, never, sometimes, about half the time, most of the time and always. Frequency of m-health use was measured in three contexts, namely, classroom, during individual or group studies and during clinical sessions or patient care. This allowed assessment of its context-specific relationships with independent variables. Independent variables for this section of hypothesis testing were gender, program level, school and socioeconomic status.

Null hypotheses $H_0 1$ to $H_0 4$ examine the relationships between gender, program level, school and socioeconomic status with m-health use status. Null hypothesis $H_0 5$ compares frequency of m-health use in the classroom, during individual or group studies and during clinical sessions or patient care. Null hypotheses $H_0 6$ to $H_0 8$ examine the relationships between gender, program level, school and socioeconomic status with frequencies of m-health use in the classroom, during individual or group studies and during clinical sessions or patient care.

5.2.1 Hypothesis tests

$H_0 1$: There is no significant relationship between gender and m-health use

At one degree of freedom, a p-value of 0.189 was obtained, therefore, the null hypothesis cannot be rejected ($\chi^2(1) = 1.722$, $p = 0.189$). As such, there is no significant relationship between gender and m-health use.

Table 5.31: Relationship between gender and m-health use status

	M-health use		
Gender	**Yes**	**No**	**Total**
Female	108	22	130
Male	112	34	146
Total	220	56	276

$\chi^2(1) = 1.722$, $p = 0.189$

$H_0 2$: There is no significant relationship between program level and m-health use

The results of a chi-square test indicate that there is no significant relationship between program level and m-health use ($\chi^2(2) = 2.583$, $p = 0.275$).

Table 5.32: Relationship between program level and m-health use status

	M-health use		
Program level	**Yes**	**No**	**Total**
1st clinical year	80	26	106
2nd clinical year	100	19	119
3rd clinical year	41	11	52
Total	221	56	277

$\chi^2(2) = 2.583$, $p = 0.275$

<u>$H_0$3: There is no significant relationship between school and m-health use</u>

The results of a chi-square test indicate that there is a significant relationship between school and m-health use status ($\chi^2(2) = 9.547$, $p = 0.008$). Looking at the observed and expected values in Table 5.33, there were significantly more observed m-health users at UDS-SMHS than expected if there was no relationship between school and m-health use. Furthermore, there were significantly more observed m-health non-users at UG-SMD than expected if there was no relationship between school and m-health use.

Table 5.33: Relationship between school and m-health use status

	M-health use		
School	**Yes***	**No***	**Total**
UCC-SMS	43 (44.7)	13 (11.3)	56
UDS-SMHS	152 (143.6)	28 (36.4)	180
UG-SMD	26 (32.7)	15 (8.3)	41
Total	221	56	277

$\chi^2(2) = 9.547$, $p = 0.008$
*expected values in parentheses

<u>$H_0$4: There is no significant relationship between socioeconomic status and m-health use</u>

The results of a chi-square test indicate that there is no significant relationship between socioeconomic status and m-health use (Fisher's Exact $p = 0.967$).

Table 5.34: Relationship between socioeconomic status (monthly family income) and m-health use status

	M-health use		
Monthly family income	**Yes**	**No**	**Total**
<GHS2,000	31	6	37
GHS2,000 – GHS4,999	38	11	49
GHS5,000 – GHS9,999	11	3	14
GHS10,000 – GHS14,999	3	1	4
≥ GHS15,000	7	2	9
Prefer not to answer	119	30	149
Total	209	53	262

Fisher's Exact p = 0.967

$H_0$5: There is no significant difference in frequency of m-health use in different learning contexts

Results in Table 5.35 indicate that there is a significant difference in frequency of m-health use in different learning contexts, namely, in the classroom, during individual or group studies and during clinical sessions or patient care. The median frequency of m-health use in the classroom and during clinical sessions or patient care were both "about half the time," while that during individual or group studies was "most of the time" (see Table 5.11). Pairwise comparisons using Wilcoxon signed-rank test (Table 5.36) indicate that the distributions of responses were significantly different for each context.

Table 5.35: Friedman test results for difference in frequency of m-health use in classroom, during individual/group studies and during clinical sessions/patient care

Test statistics	
Friedman	353.317
Kendall	0.566
p-value	0.000

Table 5.36: Wilcoxon signed-rank test pairwise comparisons

Sign	Observations	Mean rank	z	p-value
Classroom = Individual/group studies			-8.08	<0.0001
Positive	16	138.00		
Negative	104	151.27		
Zero	89	45.00		
Individual/group studies = Clinical sessions/patient care			9.59	<0.0001
Positive	126	142.48		
Negative	14	112.68		
Zero	69	35.00		
Classroom = Clinical sessions/patient care			3.76	0.0002
Positive	64	163.95		
Negative	28	162.46		
Zero	117	59.00		

The next set of hypothesis testing involves looking at the relationships between gender, program level, school and socioeconomic status on one hand, and frequency of m-health use in the classroom on the other.

$H_0$6a: There is no significant relationship between gender and frequency of m-health use in the classroom

Based on results of the Wilcoxon-Mann-Whitney rank-sum test presented in Tables 5.37 and 5.38, the null hypothesis is not rejected. This indicates that there is no significant difference in the distributions of frequency of m-health use in the classroom, between female and male students.

Table 5.37: Descriptive statistics for relationship between gender and frequency of m-health use in the classroom

Gender	Observations	Mean rank	Median frequency of m-health use
Female	104	111.48	3.0
Male	108	107.70	2.0
Combined	212	106.5	

Table 5.38: Wilcoxon-Mann-Whitney rank-sum test results for relationship between gender and frequency of m-health use in the classroom

Test statistics	
Unadjusted variance	199,368.00
Adjusted variance	172,716.23
z	1.246
p-value	0.213

$H_0$6b: There is no significant relationship between program level and frequency of m-health use in the classroom

With a p-value of 0.074, the null hypothesis is not rejected. Results from Tables 5.39 and 5.40 indicate that there is no significant difference in the distributions of frequency of m-health use in the classroom, between different program levels.

Table 5.39: Descriptive statistics for relationship between program level and frequency of m-health use in the classroom

Program Level	Observations	Mean rank	Median frequency of m-health use
1st clinical year	74	98.91	2.0
2nd clinical year	99	117.30	3.0
3rd clinical year	40	96.53	2.0

Table 5.40: Kruskal-Wallis equality of proportions rank test results for relationship between program level and frequency of m-health use in the classroom

Test statistics	
Chi-squared	5.202
Degrees of freedom	2
p-value	0.074

<u>$H_0$6c: There is no significant relationship between school and frequency of m-health use in the classroom.</u>

With a p-value of 0.024, the null hypothesis is rejected. This indicates that there is a significant difference in the distributions of frequency of m-health use in the classroom, between different schools. Tables 5.41 and 5.42 provide more details about the Kruskal-Wallis equality of proportions rank test performed. Post-hoc analysis (Table 5.43) shows that based on the frequency of m-health use in the classroom, UDS-SMHS and UG-SMD students are not from populations with the same distribution (p = 0.014). Similarly, UCC-SMS and UG-SMD students are not from populations with the same distribution (p = 0.003). In other words, the difference in distributions of m-health use frequency in the classroom, between those pairs of schools are significant.

Table 5.41: Descriptive statistics for relationship between school and frequency of m-health use in the classroom

School	Observations	Mean rank	Median frequency of m-health use
UCC-SMS	42	119.67	3.0
UDS-SMHS	147	108.25	2.0
UG-SMD	24	77.21	2.0
Total	213		

Table 5.42: Kruskal-Wallis equality of proportions rank test results for relationship between school and frequency of m-health use in the classroom

Test statistics	
Chi-squared	7.442
Degrees of freedom	2
p-value	0.024

Table 5.43: Post-hoc pairwise comparison using Wilcoxon-Mann-Whitney rank-sum test

School	Observations	Mean rank	z	p-value
UCC-SMS = UDS-SMHS			1.11	0.266
UCC-SMS	42	102.77		
UDS-SMHS	147	92.78		
Combined	189	95.00		
UDS-SMHS = UG-SMD			2.46	0.014
UDS-SMHS	147	89.47		
UG-SMD	24	64.77		
Combined	171	86.00		
UCC-SMS = UG-SMD			2.98	0.003
UCC-SMS	42	38.39		
UG-SMD	24	24.94		
Combined	66	33.50		

$H_0$6d: There is no significant relationship between socioeconomic status and frequency of m-health use in the classroom

With a p-value of 0.303, the null hypothesis is not rejected. This indicates that there is no significant difference in the distributions of frequency of m-health use in the classroom, between different socioeconomic strata. Tables 5.44 and 5.45 provide a summary of the Kruskal Wallis test of equality of proportions conducted.

Table 5.44: Descriptive statistics for relationship between socioeconomic status and frequency of m-health use in the classroom

Monthly family income	Observations	Mean rank	Median frequency of m-health use
<GHS2,000	30	99.28	2.0
GHS2,000 – GHS4,999	37	84.03	2.0
GHS5,000 – GHS9,999	9	101.72	3.0
GHS10,000 – GHS14,999	3	77.50	2.0
≥ GHS15,000	7	126.14	4.0
Prefer not to answer	116	106.76	3.0

Table 5.45: Kruskal-Wallis equality of proportions rank test results for relationship between socioeconomic status and frequency of m-health use in the classroom

Test statistics	
Chi-squared	6.039
Degrees of freedom	5
p-value	0.303

The next set of hypothesis testing involves looking at the relationships between gender, program level, school and socioeconomic status on one hand, and frequency of m-health use during individual or group studies on the other.

$H_0$7a: There is no significant relationship between gender and frequency of m-health use during individual or group studies

Based on results of the Wilcoxon-Mann-Whitney rank-sum test presented in Tables 5.46 and 5.47, the null hypothesis is rejected ($p = 0.016$). This indicates that there is a significant difference in the distributions of frequency of m-health use during individual or group studies, between female and male students. There is a significant difference in distributions although medians and modes are the same. An examination of mean ranks indicate that females used m-health more frequently than males, during individual or group studies.

Table 5.46: Descriptive statistics for relationship between gender and frequency of m-health use during individual or group studies

Gender	Observations	Mean rank	Median frequency of m-health use
Female	104	117.60	4.0
Male	110	97.95	4.0
Combined	214	107.50	

Table 5.47: Wilcoxon-Mann-Whitney rank-sum test results for relationship between gender and frequency of m-health use during individual or group studies

Test statistics	
Unadjusted variance	204966.67
Adjusted variance	188858.26
z	2.417
p-value	0.016

$H_0$7b: There is no significant relationship between program level and frequency of m-health use during individual or group studies

With a p-value of 0.431, the null hypothesis is not rejected. This means that there is no significant difference in the distributions of frequency of m-health use during individual or group studies, based on program levels. Tables 5.48 and 5.49 provide a summary of the Kruskal Wallis test of equality of proportions conducted

Table 5.48: Descriptive statistics for relationship between program level and frequency of m-health use during individual or group studies

Program Level	Observations	Rank sum	Median frequency of m-health use
1st clinical year	76	7784.00	4.0
2nd clinical year	98	11170.00	4.0
3rd clinical year	41	4266.00	4.0

Table 5.49: Kruskal-Wallis equality of proportions rank test results for relationship between program level and frequency of m-health use during individual or group studies

Test statistics	
Chi-squared	1.682
Degrees of freedom	2
p-value	0.431

$H_0$7c: There is no significant relationship between school and frequency of m-health use during individual or group studies

With a p-value of 0.658, the null hypothesis is not rejected. This means that there is no significant difference in the distributions of frequency of m-health use during individual or group studies, based on schools. Tables 5.50 and 5.51 provide a summary of the Kruskal Wallis test of equality of proportions.

Table 5.50: Descriptive statistics for relationship between school and frequency of m-health use during individual or group studies

School	Observations	Mean rank	Median frequency of m-health use
UCC-SMS	43	114.93	4.0
UDS-SMHS	148	107.05	4.0
UG-SMD	24	101.42	4.0

Table 5.51: Kruskal-Wallis equality of proportions rank test results for relationship between school and frequency of m-health use during individual or group studies

Test statistics	
Chi-squared	0.837
Degrees of freedom	2
p-value	0.658

$H_0$7d: There is no significant relationship between socioeconomic status and frequency of m-health use during individual or group studies

With a p-value of 0.549, the null hypothesis is not rejected. This means that there is no significant difference in the distributions of frequency of m-health use during individual or group studies, based on socioeconomic status. Tables 5.52 and 5.53 summarize the results of the Kruskal Wallis test of equality of proportions that was conducted.

Table 5.52: Descriptive statistics for relationship between socioeconomic status and frequency of m-health use during individual or group studies

Monthly family income	Observations	Mean rank	Median frequency of m-health use
<GHS2,000	31	93.79	3.0
GHS2,000 – GHS4,999	37	104.58	4.0
GHS5,000 – GHS9,999	9	78.00	3.0
GHS10,000 – GHS14,999	3	87.83	4.0
≥ GHS15,000	7	128.50	4.0
Prefer not to answer	117	1045.03	4.0

Table 5.53: Kruskal-Wallis equality of proportions rank test results for relationship between socioeconomic status and frequency of m-health use during individual or group studies

Test statistics	
Chi-squared	4.000
Degrees of freedom	5
p-value	0.549

The next set of hypothesis testing looks at the relationships between gender, program level, school and socioeconomic status on one hand, and frequency of m-health use during clinical training or patient care on the other.

$H_0$8a: There is no significant relationship between gender and frequency of m-health use during clinical training or patient care

Based on results of the Wilcoxon-Mann-Whitney rank-sum test presented in Tables 5.54 and 5.55, the null hypothesis is not rejected (p = 0.416). This indicates that there is no significant difference in the distributions of frequency of m-health use during clinical sessions or patient care, between female and male students.

Table 5.54: Descriptive statistics for relationship between gender and frequency of m-health use during clinical training or patient care

Gender	Observations	Mean rank	Median frequency of m-health use
Female	104	108.69	2.0
Male	106	102.37	2.0
Combined	210	105.50	

Table 5.55: Wilcoxon-Mann-Whitney rank-sum test results for relationship between gender and frequency of m-health use during clinical training or patient care

Test statistics	
Unadjusted variance	193838.67
Adjusted variance	165721.94
z	0.814
p-value	0.416

$H_0$8b: There is no significant relationship between program level and frequency of m-health use during clinical training or patient care

Based on a p-value of 0.549, the null hypothesis is not rejected. This means that there is no significant difference in the distributions of frequency of m-health use clinical sessions or patient care, based on program level. Tables 5.56 and 5.57 summarize the results of the Kruskal Wallis test of equality of proportions that was conducted.

Table 5.56: Descriptive statistics for relationship between program level and frequency of m-health use during clinical training or patient care

Program Level	Observations	Mean rank	Median frequency of m-health use
1st clinical year	75	107.60	2.0
2nd clinical year	97	108.63	2.0
3rd clinical year	39	96.38	2.0

Table 5.57: Kruskal-Wallis equality of proportions rank test results for relationship between program level and frequency of m-health use during clinical training or patient care

Test statistics	
Chi-squared	1.199
Degrees of freedom	2
p-value	0.549

$H_0$8c: There is no significant relationship between school and frequency of m-health use during clinical training or patient care

With a p-value of 0.005, the null hypothesis is rejected. This means that there is a significant difference in the distributions of frequency of m-health use during clinical sessions or patient care, based on school. Tables 5.58 and 5.59 summarize the results of the Kruskal Wallis test of equality of proportions that was conducted. Post-hoc analysis (Table 5.60) shows that based on the frequency of m-health use during clinical training or patient care, UDS-SMHS and UG-SMD students are not from populations with the same distribution (p = 0.001). Similarly, UCC-SMS and UG-SMD students are not from populations with the same distribution (p = 0.003). In other words, the difference in distributions of m-health use frequency during clinical training or patient care, between those pairs of schools are significant.

Table 5.58: Descriptive statistics for relationship between school and frequency of m-health use during clinical training or patient care

School	Observations	Mean rank	Median frequency of m-health use
UCC-SMS	42	114.95	3.0
UDS-SMHS	145	109.71	2.0
UG-SMD	24	67.92	2.0

Table 5.59: Kruskal-Wallis equality of proportions rank test results for relationship between school and frequency of m-health use during clinical training or patient care

Test statistics	
Chi-squared	10.776
Degrees of freedom	2
p-value	0.005

Table 5.60: Post-hoc pairwise comparison using Wilcoxon-Mann-Whitney rank-sum test

School	Observations	Mean rank	z	p-value
UCC-SMS = UDS-SMHS			0.58	0.560
UCC-SMS	42	97.98		
UDS-SMHS	145	92.85		
Combined	187	94.00		
UDS-SMHS = UG-SMD			3.47	0.001
UDS-SMHS	145	89.86		
UG-SMD	24	55.63		
Combined	169	85.00		
UCC-SMS = UG-SMD			2.96	0.003
UCC-SMS	42	38.48		
UG-SMD	24	24.79		
Combined	66	33.50		

$H_0$8d: There is no significant relationship between socioeconomic status and frequency of m-health use during clinical training or patient care

With a p-value of 0.504, the null hypothesis is not rejected. This means that there is no significant difference in the distributions of frequency of m-health use during clinical sessions or patient care, based on socioeconomic status. Tables 5.61 and 5.62 summarize the results of the Kruskal Wallis test of equality of proportions that was conducted.

Table 5.61: Descriptive statistics for relationship between socioeconomic status and frequency of m-health use during clinical training or patient care

Monthly family income	Observations	Rank sum	Median frequency of m-health use
<GHS2,000	31	2770.00	2.0
GHS2,000 – GHS4,999	35	3328.00	2.0
GHS5,000 – GHS9,999	9	885.00	2.0
GHS10,000 – GHS14,999	3	210.00	2.0
≥ GHS15,000	7	889.00	3.0
Prefer not to answer	115	12018.00	2.0

Table 5.62: Kruskal-Wallis equality of proportions rank test results for relationship between socioeconomic status and frequency of m-health use during clinical training or patient care

Test statistics	
Chi-squared	4.319
Degrees of freedom	5
p-value	0.504

5.2.2 Summary of hypothesis testing I

M-health use status was associated with schools; the largest proportion of m-health users was observed for respondents at UDS-SMHS, followed by UCC-SMS and lastly, UG-SMD. Frequency of m-health use was context-dependent. Although students used m-health more frequently during individual or group studies compared to the classroom or during clinical sessions, there were significant differences in frequencies of use between each pair of contexts. Frequencies of m-health use in the classroom and during clinical sessions were found to be associated with the schools that students were enrolled in. Students at UCC-SMS and UDS-SMHS used m-health more frequently in the classroom and during clinical sessions than students at UG-SMD. Frequency of m-health use during individual or group studies was only found to be associated with gender. Females used m-health more frequently than males during individual or group studies. Table 5.63 summarizes conclusions from this section of hypothesis testing.

Table 5.63: Summary of hypothesis testing I

No.	Null hypothesis statement	Conclusion
$H_0 1$	There is no significant relationship between gender and m-health use	Not rejected
$H_0 2$	There is no significant relationship between program level and m-health use	Not rejected
$H_0 3$	There is no significant relationship between school and m-health use	Rejected
$H_0 4$	There is no significant relationship between socioeconomic status and m-health use	Not rejected
$H_0 5$	There is no significant difference in frequency of m-health use in different learning contexts	Rejected
$H_0 6a$	There is no significant relationship between gender and frequency of m-health use in the classroom	Not rejected
$H_0 6b$	There is no significant relationship between program level and frequency of m-health use in the classroom	Not rejected
$H_0 6c$	There is no significant relationship between school and frequency of m-health use in the classroom	Rejected
$H_0 6d$	There is no significant relationship between socioeconomic status and frequency of m-health use in the classroom	Not rejected
$H_0 7a$	There is no significant relationship between gender and frequency of m-health use during individual or group studies	Rejected
$H_0 7b$	There is no significant relationship between program level and frequency of m-health use during individual or group studies	Not rejected
$H_0 7c$	There is no significant relationship between school and frequency of m-health use during individual or group studies	Not rejected
$H_0 7d$	There is no significant relationship between socioeconomic status and frequency of m-health use during individual or group studies	Not rejected
$H_0 8a$	There is no significant relationship between gender and frequency of m-health use during clinical training or patient care	Not rejected
$H_0 8b$	There is no significant relationship between program level and frequency of m-health use during clinical training or patient care	Not rejected
$H_0 8c$	There is no significant relationship between school and frequency of m-health use during clinical training or patient care	Rejected
$H_0 8d$	There is no significant relationship between socioeconomic status and frequency of m-health use during clinical training or patient care	Not rejected

5.3 Theoretical framework validation & hypothesis testing II

5.3.1 Theoretical framework validation

The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) was applied to asses what factors explain intention to use m-health in future and current m-health use. Partial Least Squares (PLS) path analysis with the direct effects model (without moderators) produced outer loadings of 0.7 and above for all reflective indicators, each of which was statistically significant at 5% level. The bootstrap analysis was conducted using 5,000 samples. Statistically significant outer loadings of 0.7 or greater, which are also larger than their respective cross loadings demonstrate indicator reliability (Joe F. Hair, Ringle, & Sarstedt, 2011; Henseler, Ringle, & Sinkovics, 2009). The sign of a loading does not matter in PLS analysis because the sign only indicates positive or negative correlation between that indicator and the dominant indicator. The PLS method selects one indicator with which the latent construct is made to correlate positively, and all other indicators correlate with the latent construct (Henseler et al., 2016). Tables 5.64 and 5.65 summarize this information.

Table 5.64: PLS loadings and cross loadings

Construct	Item	PE	EE	FC	HM	PV	HB	SI	BI
Performance Expectancy (PE)	PE1	**0.87**	0.75	0.38	0.52	0.01	0.06	0.27	0.31
	PE2	**0.91**	0.84	0.44	0.56	-0.03	0.11	0.20	0.28
	PE3	**0.91**	0.82	0.42	0.57	0.01	0.14	0.25	0.31
	PE4	**0.90**	0.65	0.45	0.55	0.01	0.16	0.17	0.33
	PE5	**0.82**	0.64	0.44	0.44	0.05	0.15	0.08	0.29
	PE6	**0.91**	0.70	0.53	0.57	0.08	0.12	0.23	0.28
	PE7	**0.86**	0.70	0.42	0.53	0.00	0.17	0.21	0.23
Effort Expectancy (EE)	EE1	0.68	**0.90**	0.43	0.46	-0.03	0.06	0.13	0.14
	EE2	0.72	**0.93**	0.47	0.47	-0.02	0.18	0.11	0.24
	EE3	0.81	**0.95**	0.55	0.57	0.05	0.16	0.17	0.27
	EE4	0.82	**0.95**	0.47	0.53	0.03	0.13	0.09	0.35
Facilitating Conditions (FC)	FC1	0.32	0.35	**0.70**	0.32	0.24	0.13	0.22	0.13
	FC2	0.37	0.48	**0.74**	0.42	0.13	0.28	0.28	0.19
	FC3	0.50	0.46	**0.82**	0.37	0.17	0.21	0.28	0.23
	FC4	0.37	0.36	**0.84**	0.42	0.42	0.12	0.25	0.37
Hedonic Motivation (HM)	HM1	0.60	0.54	0.51	**0.96**	0.25	0.28	0.42	0.48
	HM2	0.60	0.55	0.45	**0.98**	0.26	0.29	0.45	0.44
	HM3	0.55	0.51	0.46	**0.96**	0.25	0.32	0.41	0.49
Price Value (PV)	PV1	-0.03	-0.02	0.25	0.16	**0.75**	0.04	0.26	0.08
	PV2	0.04	0.04	0.31	0.28	**0.96**	0.01	0.34	0.27
	PV3	0.01	0.00	0.35	0.23	**0.96**	0.01	0.31	0.27
Habit (HB)	HB1	0.22	0.24	0.35	0.39	0.15	**0.89**	0.23	0.51
	HB2	-0.05	-0.08	-0.04	0.07	-0.08	**0.69**	0.08	0.00
	HB3	0.02	-0.05	-0.04	0.00	-0.08	**0.70**	0.12	0.15
	HB4	0.13	0.17	0.17	0.29	-0.10	**0.81**	0.11	0.22
Social Influence (SI)	SI1	0.16	0.12	0.31	0.33	0.32	0.22	**0.88**	0.21
	SI2	0.25	0.14	0.34	0.44	0.32	0.19	**0.96**	0.41
	SI3	0.19	0.09	0.22	0.41	0.30	0.13	**0.89**	0.23
Behavioral Intention (BI)	BI1	0.29	0.26	0.29	0.42	0.25	0.32	0.30	**0.93**
	BI2	0.31	0.30	0.36	0.44	0.23	0.39	0.31	**0.92**
	BI3	0.33	0.29	0.37	0.43	0.25	0.41	0.33	**0.91**
	BI4	0.23	0.23	0.13	0.43	0.26	0.23	0.29	**0.85**
	BI5	0.32	0.23	0.32	0.48	0.21	0.34	0.31	**0.89**

Table 5.65: Loadings, standard deviation and significance tests for indicators

Construct	Item	Question Number	Mean Loading	Standard Deviation	T Statistic	p-value
Performance Expectancy	PE1	29.1	0.87	0.06	15.64	0.00
	PE2	29.2	0.91	0.03	27.56	0.00
	PE3	29.3	0.91	0.03	26.20	0.00
	PE4	30.4	0.90	0.04	25.23	0.00
	PE5	30.9	0.82	0.06	13.75	0.00
	PE6	30.13	0.91	0.03	27.98	0.00
	PE7	30.14	0.86	0.05	17.46	0.00
Effort Expectancy	EE1	29.4	0.90	0.05	17.14	0.00
	EE2	29.5	0.93	0.04	22.00	0.00
	EE3	29.6	0.95	0.04	22.38	0.00
	EE4	29.7	0.95	0.05	17.29	0.00
Facilitating Conditions	FC1	32.1	0.70	0.12	5.83	0.00
	FC2	32.2	0.74	0.14	5.21	0.00
	FC3	32.3	0.82	0.10	8.51	0.00
	FC4	32.4	0.84	0.09	9.23	0.00
Habit	HB1	37.1	0.89	0.04	20.67	0.00
	HB2	37.2	0.69	0.15	4.57	0.00
	HB3	37.3	0.70	0.13	5.19	0.00
	HB4	37.4	0.81	0.08	9.92	0.00
Price Value	PV1	32.5	0.75	0.14	5.30	0.00
	PV2	32.6	0.96	0.09	10.95	0.00
	PV3	32.7	0.96	0.08	12.38	0.00
Hedonic Motivation	HM1	32.11	0.96	0.01	84.30	0.00
	HM2	32.12	0.98	0.01	90.78	0.00
	HM3	32.13	0.96	0.01	83.38	0.00
Social Influence	SI1	32.8	0.88	0.08	10.42	0.00
	SI2	32.9	0.96	0.03	36.65	0.00
	SI3	32.10	0.89	0.07	13.10	0.00
Behavioral Intention	BI1	39.1	0.93	0.03	34.78	0.00
	BI2	39.2	0.92	0.02	37.87	0.00
	BI3	39.3	0.91	0.03	31.16	0.00
	BI4	39.4	0.85	0.07	13.00	0.00
	BI5	39.5	0.89	0.04	22.23	0.00

Average Variance Explained (AVE) is a measure of convergent validity. According to Henseler, Hubona and Ray (2016) an AVE of 0.5 or larger is good. AVEs ranged from 0.6 to 0.94. To demonstrate discriminant validity, AVEs must be greater than the construct's highest squared correlation. For each construct, the AVE was larger than the square of each correlation as shown in Table 5.66.

Table 5.66: Descriptive statistics, latent variable correlations and average variance extracted (AVE)

Construct	BI	EE	FC	HB	HM	PE	PV	SI	Use
BI	**0.81**								
EE	0.29	**0.87**							
FC	0.33	0.52	**0.60**						
HB	0.38	0.15	0.22	**0.60**					
HM	0.49	0.55	0.49	0.31	**0.94**				
PE	0.33	0.83	0.50	0.15	0.60	**0.78**			
PV	0.26	0.02	0.34	0.02	0.26	0.02	**0.80**		
SI	0.34	0.13	0.33	0.20	0.44	0.23	0.34	**0.83**	
Use	-0.33	-0.11	-0.04	-0.36	-0.25	-0.11	0.09	-0.20	N/A

Note: Diagonals are AVEs

To further assess latent construct reliability and validity, Cronbach's Alpha, Composite Reliability and Rho-A are examined (Table 5.67). A value of 0.7 or higher is considered good for each of these (Nunnally & Bernstein, 1994).

Table 5.67: Construct reliability and validity measures

Construct	Cronbach's Alpha	Rho-A	Composite Reliability
BI	0.94	0.94	0.96
EE	0.95	1.02	0.96
FC	0.80	0.89	0.86
HB	0.80	1.02	0.86
HM	0.97	0.97	0.98
PE	0.95	0.96	0.96
PV	0.88	1.01	0.92
SI	0.90	1.07	0.94
Use	0.80	0.82	0.85

To assess model fit, the Standard Root Mean Square Residual (SRMR) is examined. According to Henseler, Hubona and Ray (2016) although some studies have pegged good model fit to be an SRMR of less than 0.05, other studies have shown that this is not a hard and fast cut-off, hence SRMRs up to 0.08 should be acceptable (p. 12). The SRMR for the estimated direct effects model of was 0.08.

For formative constructs, in this case Use, reliability and validity assessments are quite different and not as developed as those for factor models (Henseler et al., 2016). Perhaps this might be attributed to the nature of the question at the basis of this assessment, which is whether or not there is a conceptual basis for creating the construct (p. 11). Indicator weights are examined instead of loadings. Outer weights for Use indicators ranged from 0.14 to 0.29 for direct effects model. According to Hair, Ringle and Sarstedt (2011), if a formative indicator has outer weights and loadings that are not statistically significant, then there is no empirical basis to maintain that indicator and its theoretical significance needs to be re-examined (p. 145). According to Henseler, Hubona and Ray (2016) lack of significance may be due to multicollinearity among indicators, which is assessed using the Variance Inflation Factor (VIF). The VIF is a measure of the degree of multicollinearity present among the indicators. Hair, Ringle and Sarstedt (2011) recommend that VIFs should be less than 5. In the end, three indicators were dropped because (1) they had extremely low weights, or (2) their weights and loadings were insignificant at 5% level, or (3) although their loadings were significant at 5% level, their weights were insignificant to a large degree. The indicators affected were questions 24.1 (U4), 24.2 (U5) and 24.7 (U10). The remaining formative indicators had VIFs of 2 and below. After having obtained a good model fit, moderators were added to the model, namely, age, gender and experience as shown in Figure 5.13.

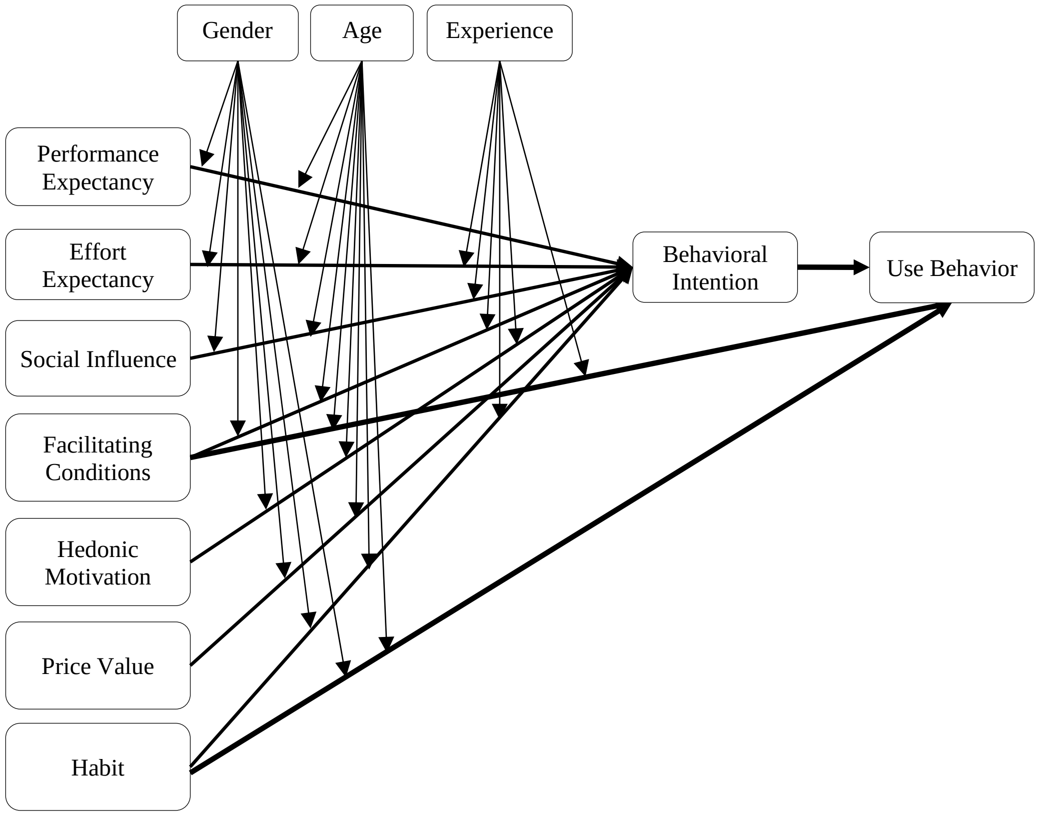

Figure 5.13: Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) (Venkatesh et al., 2012, p. 160)

The proportion of variance of endogenous constructs (BI) or dependent variables (Use) explained by their respective constructs in the model is represented by the R^2 value, which is adjusted to account for the complexity of the model and sample size. Table 5.68 shows R^2 values for the direct effects and moderated effects models.

Table 5.68: Effect sizes for the direct and moderated effects models

Dependent Variable	Direct effects model		Moderated effects model	
	R^2	Adjusted R^2	R^2	Adjusted R^2
Behavioral Intention (BI)	0.33	0.28	0.57	0.46
Use	0.19	0.16	0.32	0.26

5.3.2 Hypothesis testing II

Twenty hypotheses were tested to determine which UTAUT2 factors were significantly associated with intention to use m-health and actual m-health use as measures by frequency of use in various contexts and frequency of using various functions. Path coefficients (ß) are presented for the hypothesized relationships for both the direct and moderated effects models (Table 5.69). The path coefficient (ß) is the degree by which the dependent variable will change when the independent variable changes by one standard deviation.

Table 5.69: Structural model with path coefficients for direct and moderated effects models

Path	Coefficient (ß)	
	Direct Effects	Moderated Effects
PE → BI	0.11	0.18
EE → BI	0.00	-0.04
SI → BI	0.10	-0.02
FC → BI	0.01	-0.02
FC → Use	0.10	0.09
HM → BI	0.25*	0.39***
PV → BI	0.15	0.08
HB → BI	0.26***	0.06
HB → Use	-0.35***	-0.40***
BI → Use	-0.26***	-0.23**

Notes: *$p \leq 0.10$, **$p \leq 0.05$, ***$p \leq 0.01$

5.3.3 Summary of hypothesis testing II

Behavioral Intention (BI) and Habit were significant predictors of Use in both the direct and moderated effects models. Each of these had an inverse relationship with Use.

Habit was a significant predictor of BI only in the direct effects model, while Hedonic Motivation was a significant predictor of BI only in the moderated effects model. Table 5.70 summarizes the conclusions of hypothesis testing related to technology adoption and use, using the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2).

Table 5.70: Summary of hypothesis testing II

No.	Null hypothesis statements	Conclusion
$H_0$9a	Performance Expectancy has no direct effect on Behavioral Intention	Not rejected
$H_0$9b	Performance Expectancy has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$10a	Effort Expectancy has no direct effect on Behavioral Intention	Not rejected
$H_0$10b	Effort Expectancy has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$11a	Social Influence has no direct effect on Behavioral Intention	Not rejected
$H_0$11b	Social Influence has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$12a	Facilitating Conditions has no direct effect on Behavioral Intention	Not rejected
$H_0$12b	Facilitating Conditions has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$13a	Hedonic Motivation has no direct effect on Behavioral Intention	Not rejected
$H_0$13b	Hedonic Motivation has no direct effect on Behavioral Intention when moderated by age, gender and experience	Rejected
$H_0$14a	Price Value has no direct effect on Behavioral Intention	Not rejected
$H_0$14b	Price Value has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$15a	Habit has no direct effect on Behavioral Intention	Rejected
$H_0$15b	Habit has no direct effect on Behavioral Intention when moderated by age, gender and experience	Not rejected
$H_0$16a	Behavioral Intention has no direct effect on Use	Rejected
$H_0$16b	Behavioral Intention has no direct effect on Use when moderated by age, gender and experience	Rejected
$H_0$17a	Habit has no direct effect on Use	Rejected
$H_0$17b	Habit has no direct effect on Use when moderated by age, gender and experience	Rejected
$H_0$18a	Facilitating Conditions has no direct effect on Use	Not rejected
$H_0$18b	Facilitating Conditions has no direct effect on Use when moderated by age, gender and experience	Not rejected

Chapter 6

6 Qualitative research findings

To gain further insights into how medical students in Ghana used mobile technologies in the educational setting, focus group discussions and interviews were conducted with students, faculty members and key staff. Focus group discussions were conducted for students, where possible, while interviews were conducted for the remaining students to explore in greater depth, information gathered from questionnaires. Interviews were conducted for staff and faculty members to document their experiences and attitudes regarding mobile technology use in the educational setting. It also enabled the verification of information provided by students and vice-versa.

In total, 15 interviews and two focus group discussions were conducted. In order to protect the identities of study participants, their names were not used in this publication. Instead, they were identified using codes, along with gender, school names and program levels or departments, to provide contextual information. Table 6.1 outlines participants' profiles. Three faculty members were heads of department.

Table 6.1: Focus group and interview participants' profiles

ID	Gender	Group	Program level	School	Position
P1	F	Staff	N/A	UG-SMD	Administrator
P2	M	Staff	N/A	UG-SMD	IT Manager
P3	M	Faculty	N/A	UG-SMD	Faculty (Biochemistry)
P4	M	Student	1st clinical year	UDS-SMHS	Student
P5	M	Faculty	N/A	UDS-SMHS	Faculty (Surgery)
F6a*	M	Student	2nd clinical year	UDS-SMHS	Student
F6b*	M	Student	2nd clinical year	UDS-SMHS	Student
F6c*	M	Student	2nd clinical year	UDS-SMHS	Student
F6d*	F	Student	2nd clinical year	UDS-SMHS	Student
P7	M	Faculty	N/A	UDS-SMHS	Faculty (Physiology, ICT)
P8	M	Staff	N/A	UDS-SMHS	IT Staff and Instructor
P9	M	Faculty	N/A	UG-SMD	Faculty (Medicine)
P10	M	Student	2nd clinical year	UG-SMD	Student
P11	F	Student	1st clinical year	UG-SMD	Student
P12	M	Staff	N/A	UCC-SMS	IT Staff
F13a*	M	Student	2nd clinical year	UCC-SMS	Student
F13b*	F	Student	2nd clinical year	UCC-SMS	Student
F13c*	M	Student	2nd clinical year	UCC-SMS	Student
P14	M	Staff	N/A	UCC-SMS	Librarian
P15	M	Faculty	N/A	UCC-SMS	Faculty (Community Health)
P16	M	Faculty	N/A	UCC-SMS	Faculty (Anaesthesia)
P17	M	Faculty	N/A	UCC-SMS	Faculty (Health Information Management)

*Focus group discussions

6.1 Types and uses of information technology and m-health, and the contexts within which they are used

6.1.1 Types of information technology and m-health

Students were asked to describe some of the mobile technologies they were using, and how they used them. In addition to technologies mentioned in the questionnaire, students mentioned a few new technologies that were not captured by the study questionnaire. These included USMLE, IM Essentials Flashcards, Prognosis, Khan Academy, Clinical

Cases, Coursera, OperaMini, QuizUp, and TeachMeAnatomy. Interviews with faculty and staff members allowed them to name key technologies they had used or had observed students using. These included Google Forms, Google Classroom, Google Drive and Moodle. Table 6.2 below summarizes the number of participants who mentioned various technologies.

Table 6.2: Types of mobile technology mentioned by respondents

Apps and websites	Source
Whatsapp	P10, P11, F6a, F6b, F6c, P15, P17, P5, P7, F13b
Telegram	F6c, F6a, P11
Medscape	F13a, F13b, F13c
DailyRounds	F13a, F13c
Medshare	F13a
Prognosis	F13a, F13b, F13c,
Web MD	P10
Health Line MD	P10
Essential Hematology app	P10
Facebook	P10
Twitter	P10
Instagram	P10, P11
Sakai	P10, P11
USMLE flashcards	P11
IM Essentials Flashcards	P11
GS (General Surgery exams)	P11
Khan Academy	P11
Calendar	P11
Coursera	P11
QuizUp	F13c
Clinical Cases app	F13c
TeachMeAnatomy	P4
Blogs	P4
OperaMini	F6a
Moodle	P17
Google Classroom	P17
Google Forms	P7, P8
Google Drive	P8
Google search	P11, P10, P8, P7, P5

Devices	
Smartphone	F6a, F6b, F6c, F6d, P15, P16, P17, P3, P7, P9, P1, P8, P10, P11, F13b, F13c, P4
Tablet or iPad	P10, P11, P7, F6a, F6b, F6c, F6d
Laptop	P10, F6a, F6b, F6c
Smart watch	P7

In addition, specifying technologies they had used, participants also highlighted the degree of sophistication of these technologies and how this related to their effectiveness in teaching, assessment, learning and patient care. The utility of having smartphones with large storage capacities was highlighted by P3, a faculty member. According to him, students preferred such phones because it enabled them to capture and store a large amount of learning materials on them. A first clinical year student described how her generation has grown up with mobile technology. When they were much younger, they used cellular phones with limited capabilities popularly called "yam" in Ghana because they were big and heavy. The above sentiments are reflected in the quotes below:

> *So nowadays, if you see all of the students, they're having smartphones. And they buy the ones that have large memory, so that they can record – not only record the lectures, but also load the slides which will be given to them. (P3, male, faculty member)*
>
> *"I think with our generation, okay, my generation, it won't be that bad, because, I think, we started having phones, like, maybe primary six there. And most of our phones were the – now they call them yam." (P11, female, 1st clinical year student)*
>
> *So, they get it. And smartphones are very easy to come by these days, so almost all of them have [one]. And you'll be surprised, they have the most current smartphones sometimes, you wonder how they get them. But they have very good smartphones and they use it (P17, male, faculty member)*

6.1.2 Uses

Mobile technology was used for several purposes by students and their instructors. These include teaching and learning, assessment and evaluation, communication and information dissemination, information seeking, information capture and storage, and keeping organized.

Teaching and learning

A second clinical year student at one university talked about an instance when a lecturer tried to use a game to teach microbiology. It didn't go well due to technical issues, as indicated in the quote below:

> *I think one of our lecturers tried that once. It was a microbiology class. Microbiology. And there was this game that he had. And the game was – it was based on these microbes causing an epidemic, so based on their special qualities, how successful they're likely to be. So, in the game, you had to give certain qualities to…The microbes that we choose. So, if you choose a virus; do you want the virus to be this, this, this? And then as the game goes on, you try to do some mutations to the virus so that we end up causing a really big epidemic worldwide. So, that was it. But I think at that time, that lecture, it was more like the – I think he had to use the internet; I can't remember. But it wasn't – it didn't go really smooth…Spent a lot of time. So, he had to, like, spend time to try and start the whole thing. And I think the class, too – I don't know…I don't know if because it was a game, so most of us, we didn't really see it as a learning occasion; it was more like, oh, fun time. (F13b, female, 2nd clinical year student)*

Students were quite positive about using mobile technology for learning. While it helped to visualize concepts and systems, it also helped in memorizing as illustrated in the quotes below.

> *Yeah. But I find that using these cartoons and illustrations from the internet, yes, they really help. I'm not a mnemonic person; I forget the word. But then, like, at a point, I had to use mnemonics, and they were from those resources. I can create mnemonics, too. (F13b, female, 2nd clinical year student)*

> *I think it has really helped; because, for instance when we come to class, they use PowerPoint to teach us. You are able to visualize the thing properly; unlike those days where you have to sit down, somebody teaches you; you are just imagining. And if your imagination is not really good, you are just nobody. But it's helpful. (F6c, female, 2nd clinical year student)*

> *And it's very helpful, yeah. There are instances when a lecturer can even, nowadays teach you in a video actually. But time past, I'm sure he would have had to describe or explain it or something. Or maybe refer you to a page on a book or something. But this time, the projection, especially, it makes things very easy. (F6a, male, 2nd clinical year student)*

Assessment and evaluation

A few faculty members talked about how they used mobile technology for assessments ranging from remote online quizzes to receiving assignments via email, which students found to be very convenient. Most faculty members were skeptical about the effectiveness of using mobile technology for exams. Quotes regarding this are presented in section 6.2. The following are a selection of quotes that describe how mobile technology was used for assessments.

> *I actually did one last week for a group in Nyankpala, our other campus. And I did it in the evening. I didn't bother going there, it was in the night. I told them between 7:30 and 8:30 they will write the quiz. I sat in my room in Tamale and opened the link up. At the end of 8:30, two people were not able to do it, but then everybody else did it. (P7, male, faculty member)*

> *For most of my assignments that I give on Google Classroom, they're answered using their phones. I tell them much about it, that the app is there; you can install it on your phone. So, have it there and answer the question that way. You don't need to go and switch on your laptop or use a tablet when you have it on your phone. (P17, male, faculty member)*

> *So probably, after you are done with the work and the submission – I know of the olden days too you have to manually go and submit it to your professors. And then sometimes maybe the course rep, you have to – he'll be calling for people to be bringing theirs. But now in the comfort of your – I remember one of them, he just gave the e-mail address … So individually, you just send it to his e-mail address and you're okay. In the comfort of wherever you are. (F6c, male, 2nd clinical year student)*

Communication and information dissemination

Mobile technology was used for communication among students or between students and staff or faculty members. Mobile technology was also used for information dissemination. This information was not limited to learning materials alone but included class schedules and announcements. Most communication and information dissemination were conducted using Whatsapp. The following quotes buttress this point.

> *In fact, we use mobile technology a lot. All the student groups are on WhatsApp groups. The lecturers, we are all on WhatsApp groups. We have a whole lot of them. We have faculty-specific WhatsApp groups. We have university-wide WhatsApp groups. So, me for instance, sometimes – I mean, we use that to do everything; to share timetables, everything. To connect with the students, we use WhatsApp groups. It's better than putting a notice on any board. That's the fastest way of getting students, it's by using the WhatsApp groups. (P7, male, faculty member)*

> *At times it's very effective; especially, Whatsapp. Most of us, we are – for the past two years or three years, I think, when we are even going to prepare for exams, if not anything at all we have questions that we have been solving. The answers – that's where they put it. If you're coming for lectures, the time – every information is virtually now on Whatsapp. Everything. And we used to have the Telegram too. So nowadays – those days after lectures, I'm talking about pre-clinical, first year; we'll all be queueing to put our pen drive inside our course rep's laptop and then we are fighting to copy. But now, it's only just two people. After class, everybody is going home, because you know that it will be on Whatsapp page or Telegram, and you'll just go and download. So, I can say that everybody here has all the lectures on the phone; because you have access to it wherever you are. So, it has been very good. (F6c, male, 2nd clinical year student)*

Apart from sharing lecture slides and announcements, mobile technology was also used for circulating medical images and links to online resources as illustrated by the quotes below:

> *And again, what we also use here very much is that, we don't print hard copies of X-ray. Before, we were doing them; but now we don't do them anymore. So, when there is an X-ray, either chest, whatever X-ray it is, the CT scan; so, pictures of*

> *the CT scan images can be taken and then circulated, and then we can use it also for the teaching and learning. (P5, male, faculty member)*

> *Walking back from the ward, we are online, coming back to your room; in between, we are online. Sharing vital information amongst ourselves, vital links that we can – sites we can go to. (P10, male, 2nd clinical year student)*

Information seeking

Students used their mobile technologies for information seeking. There was a tendency for them to crosscheck some of the information they had been provided in class. This formed part of the learning process, as students were searching for further information on topics that had been taught. Although concerns were raised about credibility and trustworthiness of information, some faculty members were welcoming of the practice of students searching for course-related information on the internet. The following quotes illustrate this:

> *"And sometimes, they go on the net to fish for information" (P14, male, librarian).*

> *I use it a lot. Sometimes in the class, when there's the need. I mean, I ask them to Google; find information. A lot of the animations that we use; I get them, I put it on their platform. Just use it. I mean, they are having the technology, so put the educational materials there for them to use. (P7, male, faculty member)*

> *…we were in theater this morning and then I wanted them to find out about a syndrome. And I said I'm giving it to them as an assignment. Before I realized, in five minutes they are telling me the assignment is done. I was asking them to go to the library and go and read, and five minutes, they said well we can solve the problem here; there's no need to go to the library. And they got the answer. (P5, male, faculty member)*

> *But when we go to the wards, I mean, with the house officers and the residents – I mean, there are lots of times. You know, knowledge is not – everything is not in your head. So, when they become really tight; so, maybe, oh, their patient has hypokalemia and you've forgotten all the causes or something, then they just tell you, oh, Google; whatever you find, then we go through it, then they might coincide or something. I think that's the only time I've seen mobile technology being used effectively here; like, during emergencies or when they are not really sure about what's going on. (P11, female, 1st clinical year student)*

> *Mostly Medscape for research. But smartphones come in handy because they're available on you anytime. On the wards, you can just check up this condition or treatment for something, usually with Medscape. And usually when we're in classroom, an app like DailyRounds, it has what she mentioned, that clinical cases that other doctors or medical students have seen; you share and then you try to solve. (F13b, female, 2nd clinical year student)*

Information capture and storage

Both students and faculty members recounted several instances where they had used or would use their mobile devices to capture and store information. Mobile device cameras were singled out as being very useful for capturing or documenting rare medical conditions for sharing with students. Students sometimes made audio and video recordings of lectures for later review. Storing the same learning materials in multiple devices can have several advantages such as not losing information if one device gets damaged. The following quotes reflect the uses described.

> *"…most of them, their text books are all on their phones." (P7, male, faculty member)*

> *"They are very useful. You're able to store information. You're able to retrieve it when you need it." (F6a, male, 2nd clinical year student)*

> *"I think when I came, level 100, I had a tablet and then a laptop, and my phone, and a recorder for lectures. Because I used to sleep during lectures. I needed to revise the notes afterwards." (P11, female, 1st clinical year student)*

> *For example, I've gone to see a wound, and the wound is dirty; it is in the night. They are not there. By the time they come, the patient might have been treated. So, you'll take a picture, snap a picture, have the picture, and then when they come you can show them the picture. And that helps a lot (P5, male, faculty member)*

> *And also, to add to the – most of the mobile devices they come with, as in, recorders. So, most of the lectures, sometimes our lecturers will tell us that we shouldn't be writing anything. I'm sure maybe they have not really gotten to know that the students – some of us will put the phone on silent and then put it in our pocket; but the thing will be recording. So, after class, we go and then we make the notes from it. So, it really comes in handy a lot. (F6c, male, 2nd clinical year student)*

"There was a time where my laptop got spoilt, so, then, now it was just my phone; everything was my phone. Then when I got a new laptop, my phone got spoilt [damaged], and everything was my laptop." (F13b, female, 2nd clinical year student)

6.1.3 Use frequency

While many students were already frequent users of mobile technology prior to entering medical or dental school, other learned upon entering that they needed to have some form of mobile technology in order to succeed in school. The following quotes from a faculty member and a student illustrate this:

But what we see is that because the school has been running for the past 10 years, before you get to second year, students have gotten information from their seniors that you can't survive without a laptop, you can't survive without smartphones, you can't survive without a tablet. So, you realize that by the time they get to second year, everybody; if they don't have the smartphones, they have their laptops, everybody. So, even though it's not written down, it's not – it's like, you can't survive without it. (P17, male, faculty member)

"Well, most of us in medical school there is this not hard and fast rule of you can't do medicine without a laptop. So almost everyone; about 99.99 percent of us are using laptops" (P10, male, 2nd clinical year student)

Students used mobile technology for educational purposes frequently. The following quotes illustrate this:

In fact, we use mobile technology a lot…So, the students actually do, I daresay, even though I've not done any research – 90 percent of their learning now is done using their phones or tablets… Well, my point of view is simple. Students use – cannot stay away from their phones. So, put the learning material on the phone for them to use. That's why I give it to them. I use it a lot…I know people who swore that they'll never buy an android phone. Now, when they go for lectures, all their notes – and they are just reading from the phones" (P7, male, faculty member).

"When we are studying, from the beginning to the end, most of us have our phone beside us, unless it's charging or it's off … Very few students learn without their phone by their side." (P11, female, 1st clinical year student)

Some participants, mostly faculty members described themselves as limited users of mobile technology for educational purposes. For example, P15 said,

> *I haven't used it much, but I know people create chatrooms. If you start a new course, for instance, the class members will form a WhatsApp group and include you as a lecturer; they can ask questions and things like that. Even though I haven't used it much, but I know it comes in very handy. As for the advantages, you can't run away from. It helps. It's very, very important. (P15, male, faculty member)*

while another faculty member also said

> *"I've not used the mobile technology itself for teaching. But for example, if I go to see a patient and they are not available, then I can take pictures" (P5, male, faculty member).*

6.2 Impact of m-health use

Participants described the benefits and drawbacks of using mobile technology for teaching and learning among clinical year medical students. The main benefits were convenience and ease of doing things, saving or maximizing time, interactivity, getting instant feedback and other information, having access to international expertise, and cost-savings. The main drawbacks mentioned were distraction and time wasting, credibility of online information, inappropriate uses, potential for abuse and demotivating knowledge and skill retention.

6.2.1 Benefits

Convenience and ease of doing things

Students, staff and faculty members expressed how mobile technology made various aspects of teaching and learning simpler, easy or more convenient. According to a faculty member, once very reliable systems are put in place, technology makes life easier. He said,

> *But I think it's a good thing. If it can be done, if it can be done and done properly, why not? Technology makes life easier for everyone…Especially, mobile, it makes it easy to send and receive information in real-time. (P15, male, faculty member)*

He had earlier mentioned that it was almost impossible to teach without using ICT, for example, searching for up to date information using the internet, or using PowerPoint for presenting slides. To him, using mobile technology offered the same benefits as using ICTs in general by making it more convenient.

> *It makes teaching and learning more convenient. So, I can cite a simple example. There was a day we had lights out; a lecturer was teaching, and the lights went out, you know Africa and our problems, lights went out, so the projector goes off, but the lecturer still has his laptop with the slides on it, so he can teach. So, what he quickly did was to send them the slides via WhatsApp, send it to the class group. So, he sends it once and everyone gets it. So, as he's teaching without the projector, they can follow on their phone. So, like I said, it comes in handy. It makes teaching and learning more convenient. Especially, mobile, it makes it easy to send and receive information in real-time. (P15, male, faculty member)*

Seeking information using their mobile devices was convenient for students because it saved them from carrying heavy books as attested to by the following quotes:

> *"So, it's been good really, especially in the area of question solving, where we don't have to now go to the library, go and pick up books – just go online and we're there." (P10, male, 2nd clinical year student)*

> *It is handy. It is easily available, and maybe if you are going on ward rounds and maybe there's a case you're talking about, you can't go back for your huge books. It's just there, you just type, and you can get the information. And you can read alongside what he is also teaching at that particular time. So, it easily helps you to follow whatever you're doing during ward rounds. And you get the understanding. (P4, male, 1st clinical year student)*

> *…when we're in school, we can't carry most of our books along with us. And some of us don't do very well with soft copies. You get it? So, when we have these*

> *technologies on our…where you ask a question, someone can answer easily, that kind of thing. (P11, female, 1st clinical year student)*

Instant information or feedback

Mobile technology was very useful in enabling students obtain precise information instantly and providing them instant feedback regarding their knowledge and skills. The following quotes illustrate this:

> *My perception about them is they are quite precise. So, going through books to find out those various [pieces of] information will be quite cumbersome. But they have given you – they have done the work that you're supposed to do on your own. And they have put the information there. It's simplified, and it's straight to the point. (P4, male, 1st clinical year student)*

> *And, like, for the app I was saying, with the podcast on emergency medicine and then all those things, it's easier because it's like your lecturer is lecturing you, but they're giving you the salient points. You know, usually, when they do these audios and videos, they don't talk about everything; they give you, like, the most important things to know and all that. (P11, female, 1st clinical year student)*

> *One thing good about this is, the students have immediate impact or immediate feedback. So, you know where you are wrong, so that next time you know where to correct. It's instant; you don't have to wait until another day or two before you know, question A, question one, this is the answer; question B this is the – no. That one, the feedback is instant. (P3, male, faculty member)*

Time-saving or time maximization

Students experienced heavy demands on time and therefore had a tendency to want to maximize the little time they had. As such, they used mobile technology whenever there was little free time such as when waiting for the next lesson to start. Owing to the portable nature of their devices, students were able to use them while performing other tasks such as walking home. The following quotes aptly capture this sentiment:

> *So, if I cook, I eat, you sleep. There are lots to learn, a lot to go through. So, I get on my laptop, by 12:00, time will be far spent; you'll sleep, you have to wake up early. So, I don't get to use those apps during the night. But during the day, there are a lot of – like, the lecturer hasn't come to class; like, I'm not in a conducive*

state or environment. So, when I'm walking from my hostel – it's far; I think it's a 30-minute walk…While I'm walking from my hostel back, I listen to the news online…So, say, for emergency, internal medicine, take one topic; so, when I'm walking from school back to the hostel, maybe a particular topic or it's theory we're having the next day, all I have to do is listen. And, you know, when you listen, too, things get stuck faster.…And then, mid-lecture periods, I'll read news on Joy online. That's the only app I have for Ghana news. (P11, female, 1st clinical year student)

Usually, in between lectures, in between ward rounds, because you can't really use it in the classroom when the lecture is going on. And on the ward too, because more of the one on one something, you really can't pull out your phone and online. So usually when we are waiting for the lecturer, we are online. Walking back from the ward, we are online, coming back to your room; in between, we are online. Sharing vital information amongst ourselves, vital links that we can – sites we can go to. (P10, male, 2nd clinical year student)

Students preferred time-saving ways of doing things such as being able to email an assignment as opposed to writing it by hand or printing it and handing in the hard copy. Time-saving benefits of mobile technology were seen in class and clinical teaching contexts, as well as individual learning instances. This is vividly illustrated in the two quotes below:

"Using it in clinical teaching, yes. I think it saves a lot of time and a lot of energy, and it will increase the efficiency." (P15, male, faculty member)

But smartphones come in handy because they're available on you anytime. On the wards, you can just check up this condition or treatment for something, usually with Medscape. And usually when we're in classroom, an app like DailyRounds, it has what she mentioned, that clinical cases that other doctors or medical students have seen; you share and then you try to solve. (F13a, male, 2nd clinical year student)

Participants talked about being able to do things in real-time or getting feedback instantly. This saved them from having to be physically present or waiting for information to be sent to them at a later date. A couple of quotes illustrating this can be found below:

Sometimes when something is happening in the US or India, you can see it in real time. You see it in real time, and the procedure. So that specialist doesn't have to *be here in person before he can direct you as to what to do; and you see it in real time. (P3, male, faculty member)*

In relation to the assessment too, in most of our – we are quite a number, so sometimes if we write an exam, it has to take time for them to mark. And by the time you'll even see your results, maybe it's two weeks to a month. But when it is online, as soon as you finish, I mean, answering the questions, then it will generate your score for you. Then you know what you've gotten then you can move ahead too. (F6a, male, 2nd clinical year student)

Electronic medical records system came up as having the potential to save time with respect to finding and accessing patient records and fulfilling prescriptions. This is depicted in the following quotes:

I think that, basically when you take some of the folders you can't see. So, the patient will send the folder to the pharmacy, the pharmacy will return to the doctor; the doctor will say, can't you see; can't you see. [Laughter]. So, it's time consuming; because you have to now write and send it. So, I think if it comes in handy for us to just – maybe a software or something where you can really send folders in between the hospital and all that. (F6d, female, 2nd clinical year student)

I've been to a hospital where they don't even use the folder system again. They just have your information on their data system. So, when you come, all what the doctor has to do is to key in your name and then some other things. Then your information comes; so, he reads the previous history and then the diagnosis and everything. Then, I mean, he would move on from there. So that's a bit easier. And then the folder system – in case your folder is missing, it means that whatever was wrong with you previously, the doctor now attending to you will not even know. Especially if that person did not attend to you previously. So, he would have to start the whole process again; and it's time wasting for the patient and for you the doctor as well. (F6b, male, 2nd clinical year student)

Interactivity

On interactivity, opinions were divided. For example, a staff member talked about how incorporating the use of mobile technology in teaching can help to improve human interactivity in class as shown in the quote below.

So, if you make them understand they need to do even 70 percent of the research before they even come to class; in that sense it's going to help with the teaching *and learning, and then the class teacher-student interaction. Because once they are able to easily access information with the mobile technology, it makes it easier for them to be able to [contribute] … So, with the mobile app, it's going to rather diversify students' mind on – you know. (P8, male, IT staff and instructor)*

A faculty member, on the other hand, feared that the use of mobile technology for distance learning may reduce teacher-student contact time. He said:

It's also very good. It might – but the fear is, using smartphones and all means that it might reduce student-lecturer contact time. And then students might prefer to stay in their hostels and rooms and, feel like if they go, they know what will happen. They can watch the lecture from their office. (P9, male, faculty member)

Another interviewee, a student, described how an interactive psychology app helped her practice how to listen to patients and engage in dialogue with them.

When I'm tired, just to go through it. And for the Seven Caps, I think Seven Caps, I usually do it in the evening because it's quiet; I'm not getting people talk to me, so I can listen to the patients very well…So, there are listeners and there are people who come with problems. So, you can choose to be a listener, or you can choose to come with an issue. So, all you'll do is – I think the initial stage is sort of like an online training, so you answer some questions, they'll teach you some things, like, someone comes, maybe they write, answer it, and so if you can handle it, you talk to the person. So, it helps me, as in just to get more patient, as in, not to lose my emotional touch when it comes to patients, that kind of thing. And then the rest are not medical – (P11, female, 1st clinical year student)

International expertise

Students also benefited from the knowledge and expertise of experienced doctors from all over the world. Asking colleagues questions online can be helpful, although sometimes, there are no responses. This is one drawback. Below are a couple of quotes addressing this issue:

So, we discuss medical cases. I mean, I'm first clinical now, so most of the things they discuss, I'm not abreast with, so I can't really give any information. But it helps me follow up. And, I mean, doctors all over the world, US, India; everyone

> *is just on board. So, this one is saying, oh, in India, this is not the commonest cause, this one, so it makes you more (P11, female, 1st clinical year student)*

> *I remember, there was this one time, we set up a group like that, and you'll put a question there and…nobody really answers. I really don't know, whether it was because they didn't have time to type the whole thing. But, usually, when you meet them upfront and you ask them…they'll tell you. But put the question there and…once in a while, but it wasn't really effective. (F13a, male, 2nd clinical year student)*

Cost-saving

Lastly, cost came up as an important benefit. Some participants, mainly faculty and staff, were of the view that using mobile technology for medical educational purposes could bring some cost-savings to their schools and themselves. For example, P9 said, "mobile technology may be cheaper as compared to a fixed I.T. like…desktops and laptops and that kind of thing" (P9, male, faculty member). Although laptops are also mobile devices, P9 likened it to a desktop computer due to its costliness. An administrator and an IT person, from different schools, compared the costs of office stationery and equipment for information dissemination to that of using mobile technology for the same purpose. The IT person said: "It can have cost savings for school and students compared to using paper and pens" (P12, male, IT staff). The following quotes illustrate this point further:

> *It's time saving, cost saving and all those things. Where you would have to – then it means we have to go paperless; which will save a lot. Because toners now are very expensive. Papers are expensive, you need the printers, you need computers and all these things. And now the school cannot afford because of our financial situation. So, it is a good idea" (P1, female, administrator)*

> *Yeah. It could help, because they can just demonstrate it, and maybe the facilitator will be at one end. It's not necessary for him or her to travel to where the students are. So, I think if we are using the video call for assessment, it can also help, cost-wise. Cost-wise, it will help. (P14, male, librarian)*

6.2.2 Drawbacks

Distraction and time wasting

Although social media, especially Whatsapp was hailed as providing numerous benefits to students and faculty, social media in general can be distracting when used both in and out of class. Students described getting distracted by pictures and messages from other friends who come are online at the same time. As a result of this distraction, time gets wasted. The following selected quotes illustrate this:

> *But the other side of it is that students take these things to classrooms and they are not – they don't concentrate. They may be doing Facebook and other things. Whatsapping and listening to YouTube and other things whilst teaching is in progress. So that's the other side of it. (P1, female, administrator)*

> *Even as much as – and for me personally, the social media that I think can aid this academic progress is Whatsapp, and I think Telegram; but we no longer use Telegram, because you can now send documents on Whatsapp. But for others like Facebook and Twitter and Skype; to me personally, they hinder actually in a way. Because this is the time, you have an exam and then you – you are just passing by, you just open Opera Mini and then there's a pop-up. A friend just says hi, then you go and then you spend time, you just can't leave them. So, you look back and it looks like you are taking some time off for it, which could have been used for studies. Even as others help; others also, they sort of – they are an impediment, actually, in a way. (F6a, male, 2nd clinical year student)*

> *… with the conventional textbook, I can just pick my textbook, my notepad, my pen and walk to the library and get to study. But now with my tablet, on my iPad, or even my phone; it's connected to my WhatsApp, it's connected to my Facebook, my Instagram, my Twitter. So now, as my data has to be on, or I'm connected to the internet, definitely, I'm going to receive notifications. So, there's that drawback where I'm not 100 percent concentrating on what I'm studying online; and therefore, I have to. (P10, male, 2nd clinical year student)*

> *But like my friend said, it's very distractive. If you don't control yourself, you'll end up all the time Facebooking and Whatsapping, and you can't really study as you're supposed to. (F6d, female, 2nd clinical year student)*

According to students, many of their instructors saw mobile technology as a source of distraction so they tended to restrict its use. Faculty members confirmed students' perceptions. Below are quotes from students and faculty members in this regard:

> *"They haven't – not all though. Most of them haven't. Most of them see it as a number one distractor. Most of them see it as, you can't study" (P10, male, 2nd clinical year student)*
>
> *It will be very good when they kind of incorporate it in their lectures. But they think it will be a source of distraction. That is why maybe they might – they are feeling – they are not actually incorporating it in their study. They think it will distract us. (P4, male, 1st clinical year student)*
>
> *Personally, I think, while the class is going on, you should pay particular attention; because it's just a lecture. The lecture is giving you a broad idea of what to read about. It's not like a teaching session really. So, after the lecture, carry on your own research (P9, male, faculty member)*
>
> *But about students using mobile technology in the classroom; as for classroom, I don't. Because they disturb. You don't know whether they're paying attention or not. And you know some students, they'll be using it for their social chat and other things, and you cannot tell whether they're using it for your thing. (P16, male, faculty member)*

Credibility of information

Participants were sometimes concerned about the trustworthiness of information on the internet. This stemmed from students' lack of knowledge and experience in finding credible information. As such, some faculty members discouraged them from searching for information on Google, for example. The following quotes illustrate this:

> *That has always been a headache…So that is why sometimes our lecturers will tell us not to visit the internet for our information. Because we are not matured yet to know what is good and what is not good. We are still in school, and some of the information, we might have it as a trusted source, and you might be reading, which may not be accurate. So that's why sometimes, our colleagues and our lecturers, they don't encourage us to – because we can't filter out what is good and what is not good, sometimes. (P4, male, 1st clinical year student)*
>
> *Sometimes they have the internet available, but they don't even know where to find the right information; credible information that would assist them or guide*

> *them in their research work. So, I don't know if there could be a platform, actually, where students could easily refer for … when they are seeking some information. (P8, male, IT staff and instructor)*

> *And, usually, they're not very confident about information online. I think that's where the main issue comes from. Because when they come to class and, like, oh, we read this from here; they'll tell you, don't trust Google, don't do this. So, I think that's where the issue with the mobile technology comes to play. (P10, male, 2nd clinical year student)*

At one university, students are taught how to appraise online information. This is described in the following quote:

> *But from the first day they enter the second year; they come the second year, first week, we introduce them to medical studies and how to appraise information online, how to judge information online – the quality of information online, are all taught. So, they know how to appraise the information and decide if it's coming from the right source. (P17, male, faculty member)*

Inappropriate use

Inappropriate use also came up as one of the drawbacks of using mobile technology in the learning environment. Owing to the fact that mobile devices can perform many functions, it is difficult to control what it is used for. The two quotes below illustrated inappropriate use of mobile technology in clinical and classroom settings respectively.

> *And then issues of professionalism. But the danger is, you go to the ward maybe for dissection, and somebody is taking a selfie with a cadaver to post on Facebook. (P7, male, faculty member)*

> *And they may be using it inappropriately. They'll take pictures and other things which are not appropriate. So, in the classroom, no. (P16, male, faculty member)*

Potential for Abuse

Participants expressed concern about possible abuse of mobile technology when used in the learning environment, especially when it comes to exams. The greatest fear was cheating in exams or assignments. For example, when asked about using mobile technology for exams, a faculty member said, “Wow. That one, really? Come on, they will just copy from the internet. For me, especially, now, assessing, I don’t think we are there yet. I don’t think we are there yet” (P15, male, faculty member). Another faculty member was of a similar view. He said, “Well, the only disadvantage, I think, is cheating” (P3, male, faculty member). Almost all participants talked about the risk of exam malpractice or cheating. Here are a few selected quotes.

> *I think, basically, I think it’s good; but I think it needs also – it has got some disadvantages if you’re not careful. For malpractices. It can be used for malpractice, but apart from that, I think the advantages overweigh the disadvantages. (P5, male, faculty member)*

> *For assessment, mid-semester, end of rotation, end of course; it might be difficult using mobile technology, especially. It will encourage a lot of copying among students. And that might generate insincere responses. We might get very poor candidates passing through because they are just – even the current system we do, that’s why we don’t even do a lot more of homework and that kind of thing. (P9, male, faculty member)*

> *Yeah. And the final thing, too, would be the fact that there would have to be some kind of ethical code for the students. Because if you try to move exams to information technology and m-health applications or whatever, I mean, obviously, you can “cheat”. So, that’s also a downside. (F13c, male, 2nd clinical year student)*

Some participants suggested strategies for limiting cheating. One faculty member was of the view that if the exams are designed appropriately, chances of cheating will be limited. Strategies include having a tight time period for exams, crafting application questions that rely on critical thinking and holding such exams under physical supervision. These are exemplified in the quotes below.

> *They really can’t. It depends on – my belief – it depends on the type of questions that you give, and then the number and then the duration. In fact, the first one I did for that large class, I didn’t bother going to the class. Because they start at eight and end at nine. I sat here and told them they should start work. Everybody thought they could cheat. But you know, MCQ for you to answer, to Google, you*

have to weigh each of the answers to know whether it is right or not. And if I give you an hour to answer 60 questions, you cannot do that. And so, the result of the quiz, you could see their normal distribution in it. I mean, nobody got every question correct. You could see those who don't do well were still getting the 12 over 50 and you could still see the trend in it. I was actually surprised, because I was thinking in my absence, everybody will get everything correct. (P7, male, faculty member)

And for the exams, quizzes and assignments; probably assignments. But quizzes and exams, if it's in classroom under supervision, I think it's okay. But if they will be on their own, then I'm sure cheating will…occur. So that one too it has its good side and its downside. (P1, female, administrator)

Demotivates knowledge and skill retention

One student admitted that mobile learning can make students a bit lazy. According to her, there was a tendency to put in less effort at knowing and memorizing information because everything is a few clicks or taps away. Similar sentiments were shared by another student from a different school. A faculty member talked about the risk of reducing class attendance if lectures are streamed or recorded and made available online. Below are quotes for these respondents.

So, when they see you with a phone, it's like you're lazy. And I won't deny that fact. It doesn't make us want to – you know, every time a lecturer says something in class, everyone just grabs their phone. We don't really memorize too much, that kind of thing, because we always have what we need at our finger tips. (P11, female, 1st clinical year student)

Actually, if it was limited or inaccessible, it would have driven you to a more comprehensive process of getting that information. So, I think those are the main problems. Because medicine now becomes just answer-based as opposed to understanding, if you depend so much on it. (F13b, male, 2nd clinical year student)

And then students might prefer to stay in their hostels and rooms and, feel like if they go, they know what will happen. They can watch the lecture from their office. (P9, male, faculty member)

6.3 Facilitating conditions of m-health use

The main facilitating conditions identified by participants during interviews and focus group discussions were availability, quality and reliability of technology, technical support, security, cost, technology competence and training, portability, task and goal fit, social and organizational factors.

Availability, quality and reliability of technology

Participants identified the availability of services such as electricity and internet as very important for the effective use of mobile technologies for educational purposes. Where these services were available, they remarked about their quality and reliability. The following quotes illustrate this.

> *"Mobile technology is good, but in our setting, we need to have functional, reliable internet services, to get that very effectively" (P9, male, faculty member)*
>
> *But I think it's a good idea. If only the system can support it. If we have systems that can support it; technology that can support those things. Currently, our internet thing is not too good. It's not too strong as one may expect. (P1, female, administrator)*
>
> *Data. Usually, because I usually access m-health on my smartphone, I'd have to get the data myself. If you want to get Wi-Fi, you need to go into the library to access it. Be in the library. And even sometimes, slow. It depends; for me, the major slip back has been… (F13a, male, 2nd clinical year student)*

IT directorates, departments and units (DDUs) provide various services to enhance ICT use in general. In all the schools that I visited, ICT DDUs provided wireless internet services. At the time of data collection for this study, work was ongoing to extend high speed internet service to all departments at UG-SMD using fiber optics. According to P2, work was also ongoing to provide internet interconnectivity between universities in Africa, as illustrated in the quote below.

…we are also trying to get in eduroam. Eduroam is inter-university wireless connectivity. So that means if I'm from University of Ghana and I get to KNUST, I don't need anything. All I need is my credentials from University of Ghana, I can connect to the internet. If I move from here to Uganda University, I should be able to connect. (P2, male, IT manager)

Two students talked about the reliability of their mobile devices and the risk of losing stored information, as depicted in the following quotes.

There was a time where my laptop got spoilt [damaged], so, then, now it was just my phone; everything was my phone. Then I got a new laptop, my phone got spoilt, and everything was my laptop. And so, then, getting access to the internet became a problem. Then I had to use a modem. And then the modem, too, is not predictable. So, technology hardware, that's the problem. But now, it's better. (F13b, female, 2nd clinical year student)

And I also believe that there are times that you can equally lose your materials; like things you have actually saved. Especially on laptops when it's a crash or something. (F6d, female, 2nd clinical year student)

Security & technical support

In terms of technical support, an IT staff said his unit provided services such as assisting members of their university communities to configure their devices to connect to the internet, email setups and software licensing. This is vividly illustrated in the quote below:

On daily basis that's what we do. Probably, my Microsoft Office is not…is expiring or not working. My Windows, my phone is not able to browse. Mostly the mobile … Connecting with their credentials becomes a problem, mostly through their mobile phones and tablets and palm tops and those things. So, they have to – they run here daily. (P8, male, IT staff and instructor)

Issues of security revolved around three main concerns: system security, information security, and privacy. First, participants raised concerns about security of infrastructure, devices and programs running on them. P16 felt that commercial software was too expensive, so he felt perhaps developing a unique learning management system would be better. However, he cautioned that this could be vulnerable to hackers. He said, "So, I think they can do those. But they're expensive. That's the problem. So, maybe, you have to develop something unique. But those ones will be hacked" (P16, male, faculty member).

A student recounted a time when her school's e-learning platform was hacked. Furthermore, an IT staff described how malware and viruses caused havoc for some members of the university community and how his unit was managing it. Lastly, a second clinical year student recounts an unpleasant experience with malware. The details of these experiences can be found in the following quotes:

> *We had this e-learning platform on our school website. But there was a time that the website was hacked. And then when it got hacked, all of us – like, everything was lost. So, they had to redo the whole thing, and then… (F13b, female, 2nd clinical year student)*

> *Because there are most of the cases; viruses really worry some of the lecturers. They lose all their materials, and then it becomes a problem. So, we actually give them training on how to use some of these tools to be able to enhance their teaching and learning. (P8, male, IT staff and instructor)*

> *One time my friend introduced me to a website and I went, there was this man that I really like; he's good. So, I was going to download. And because, the way they captioned the thing, it was one of the books that I was really looking for. So, when I saw it, I fully went and downloaded it. When I came back, any other thing that I want to do, the phone will be doing its own thing… I tried deleting it. So, I had to finally restore to factory settings. And then I lost everything. That day, all my Whatsapp chats, everything didn't come; my books, everything got lost. So, I went back, and I was telling him that he has introduced me to…he caused it; but then I knew that it was a malware. So, it means that you also have to – the training, you have to be very careful. You have to be trained to know… (F6c, male, 2nd clinical year student)*

Aside system security, copyright and information security came up. One faculty member was of the view that course material should not be sharable with people who are not enrolled in those courses. He thought that the ideal e-learning platform should not allow this as depicted in the following quote:

> *But I don't want the one that they will use, and they'll be using your information and passing it on to people, and then anybody can access it. That one, I… But if there's a way that it would be such that it's not disseminated outside and then used, and then it will be better. (P16, male, faculty member)*

Lastly, personal information and privacy came up. P11 was not comfortable passing her personal information to apps and people she didn't know. She was concerned about the risk of being a victim of fraud, but described how she was facing up to the risk in the following quote:

> *And then, I wasn't really comfortable giving out personal information online. But now, almost every business is an online business, so I had to climb that mountain, face that challenge of giving out personal information. Because you don't know who you're talking to; you can't really verify. But so far, so good. Most of the online businesses I'm into or online stuff I've done, I've not really encountered any fraud or those issues. (P11, female, 1st clinical year student)*

Cost

Cost emerged as an important factor for facilitating m-health use. Some participants saw significant costs associated with using mobile technology in the study context. These costs were mainly associated with acquiring good quality programs and apps, and devices. There was also the cost of having a personal data package, and the cost of providing alternative power when the electrical grid was down. A few quotes exemplifying these are as follows:

> *"the very effective apps, the ones that really help me, demand a lot of data. That means, I have to spend a lot of money" (P11, female, 1st clinical year student)*

> *My drawback would be in terms of cost. Some of the apps, most – let me just use some; some of them are free, and some are quite expensive, you have to pay. There was this one app that I saw was really interesting and I thought would*

really benefit me if I would get it, but then I had to pay for it, and it was really expensive. So, most of the apps that are coming out now, you need to pay for it. (F13a, male, 2nd clinical year student)

A couple of weeks back there was a substation that was burnt down. And then for days there wasn't electricity. So, the cost of trying to get alternative source of power to be able to sustain these mobile technology devices is also a challenge. (F6a, male, 2nd clinical year student)

Aside that too, I think that one of the challenges is that – I believe almost everybody will want to use the smartphones, but the cost. At times the cost; especially the very good ones. Not everybody is able to afford those…Uh-huh, and you'll buy some that is not really good. In some few days it's spoilt, you have to look for money and buy. So, the cost – the cost. (F6d, female, 2nd clinical year student)

Competence and training

Some participants described their competence levels or those of other social connections in relation to how it affects mobile technology use. Generational culture came up as an important reason why some faculty members did not use ICT very much. The following quotes describe competence levels of some participants.

…then the only other thing is that you should do the thing in such a way that the old-fashioned people and then…People who are not – you see, these computer whiz, they can bamboozle you and go and do certain things, and if you're not careful, everything will be in a mess. So, when you're doing anything, you should take that into account, that a lot of lecturers, they are from varying backgrounds (P16, male, faculty member)

You can count the number of lecturers who actually like using technology. So, because maybe they weren't trained that way. So, for them, they see it to be mainly a distraction. And very few would want to implement using various aspects of this technology into their teaching. (F13c, male, 2nd clinical year student)

I can tell you that some of our old-time professors, they still write on the board. [Laughter]. Yes, I'm telling you. They don't want to project slides or whatever it is. Yes, you see there's nothing wrong projecting and writing if you want to lay emphasis. But they want to write on the throughout, because probably they can't prepare even PowerPoint slides. So, these are some of the defects we have in our community. (P3, male, faculty member)

Participants also talked about a need for training in order to effectively use mobile technology for teaching and learning. Training would help ensure a good level of competence for students, staff and faculty members. Sample quotes illustrating this are as follows:

> *There must be training. Even among lecturers, not everybody is conversant with the common PowerPoint and Word and things like that ... So, in our part of the world, we can apply it, but at the universal level, there'll be huge challenges, huge challenges. (P15, male, faculty member)*
>
> *Moodle, yeah. I've used that. And we're planning to activate it again. We realize that some of our lecturers still need a lot of training on Moodle. They need a lot of training on that. We've done about three trainings. But by six months, they have forgotten; you have to now…refresh them (P17, male, faculty member)*
>
> *Plus, training. Training of the people. For me, my typing speed isn't so fast, so between writing and typing I would prefer to write, because I'm faster that way as compared to – (F6a, male, 2nd clinical year student)*

Portability

Participants identified portability as one of the factors that makes using mobile technology for teaching and learning easy. Owing to their relatively small and compact designs, coupled with large storage, it was easy to carry mobile devices around with lots of learning materials on them. This enabled participants to use them wherever they were. The following quotes illustrate this

> *But smartphones come in handy because they're available on you anytime. On the wards, you can just check up this condition or treatment for something, usually with Medscape. (F13a, male, 2nd clinical year student)*
>
> *It is handy. It is easily available, and maybe if you are going on ward rounds and maybe there's a case you're talking about, you can't go back for your huge books. It's just there, you just type, and you can get the information. And you can read alongside what he is also teaching at that particular time. (P4, male, 1st clinical year student)*

> *After class, everybody is going home, because you know that it will be on Whatsapp page or Telegram, and you'll just go and download. So, I can say that everybody here has all the lectures on the phone; because you have access to it wherever you are. So, it has been very good. (F6c, male, 2nd clinical year student)*

Task or goal fit

According to the participants, how mobile technology are used in assessments should match the specific goals of the assessment. As such, mobile technology may be appropriate for multiple choice question (MCQ) exams, but not for objective structured clinical exams (OSCE) as described by two of the participants in the quotes below:

> *It depends on how – the type of questions that the students are asked to answer. If it's multiple choice questions, then that is possible. But as medical students, sometimes it's good for them to answer short essay type of questions. Because at the clinical years, they are going to consult. So, they are going to communicate, they are going to diagnose and so forth. So, they need to be articulate. So, if it's just MCQ, multiple choice questions, where they have to select the best answer out of four or five, they will not be able to coordinate their thoughts well. So that is the only disadvantage I foresee in using that type of test. (P3, male, faculty member)*
>
> *For mobile technology to take over our examination structure and everything, I don't think it's a good idea. Because some of our exams are clinical and, see, we run OSCE and…and these are required in your clinical practice. You need to go hands-on, how to examine the patient. So, it's good for your learning and preparation. But then for the actual…exam…[It won't be helpful] especially for the clinical side…MCQ, fine…But for the clinical aspect, it's…You need to have hands-on… (F13a, male, 2nd clinical year student)*

For some students, it was important that the mobile technology suited their learning styles. A sample of quotes alluding to this are as follows:

> *I think ever since I came, I've always been somebody who likes being online. So, for me, it's more of, it's helped my curiosity, because of the fact that there's so much you can get exposed to through m-health and m-health technology. (F13c, male, 2nd clinical year student)*
>
> *When I'm studying, I usually like to read, like, book. I prefer reading before going online; like, trying to understand before. And I use a lot of time to read, so I have little time to go online and search. Yeah. But I find that using these cartoons and*

> *illustrations from the internet, yes, they really help. I'm not a mnemonic person; I forget the word. But then, like, at a point, I had to use mnemonics, and they were from those resources. I can create mnemonics, too. (F13b, female, 2nd clinical year student)*

Social factors

While some faculty members encouraged mobile technology use in the classroom and in the clinical setting, others tended to restrict use. The following are a few examples where faculty members encouraged use.

> *"But I will encourage this type of use of information technology to enhance teaching and learning." (P3, male, faculty member).*

> *But with the lectures and tutorials, we don't stop them at all. In fact, [in] the tutorials, it is actively used. Because most of them, their textbooks are all on their phones. Initially, people resisted but then you can't stop them, out of probity. (P7, male, faculty member)*

> *… you the lecturer should devise the measures that will compel them to do it on their own. So, because of that, I wouldn't give you detailed information on the slide for you to read and then you sleep. But I give you just the points, and then I don't explain much of the points in the slide. So, I tell you to go, you have tablets, you have phones, you have laptops; there's internet available. Do the research on your own (P8, male, IT staff and instructor)*

Other significant social connections also had a role to play in encouraging m-health use as illustrated below by one of the participants:

> *But till my dad – he worked outside [the country]; he has a much broader idea. So, he came back, oh, do you have this app? You know, there are some apps – I think it's called Coursera. Yeah. And there's Khan Academy. So, you go, whatever course you want to study… (P11, female, 1st clinical year student)*

Students found out about new technologies from colleagues. One student recounted being introduced to a website by a colleague. A faculty member also explained how seniors passed down information to juniors about the necessity of having mobile technology in medical school. These experiences are succinctly described in the quotes below:

> *One time my friend introduced me to a website and I went, there was this man that I really like; he's good. So, I was going to download. And because, the way they captioned the thing, it was one of the books that I was really looking for. So, when I saw it, I fully went and downloaded it. (F6c, male, 2nd clinical year student)*
>
> *But what we see is that because the school has been running for the past 10 years, before you get to second year, students have gotten information from their seniors that you can't survive without a laptop, you can't survive without smartphones, you can't survive without a tablet. So, you realize that by the time they get to second year, everybody; if they don't have the smartphones, they have their laptops, everybody. So, even though it's not written down, it's not – it's like, you can't survive without it. (P17, male, faculty member)*

Some significant social connections, mainly faculty members restricted mobile technology use in certain contexts. One student recounted that while teaching was ongoing, faculty members did not like to see students on their phones. Even when students sought permission to use their phones, they are denied. She said, "While they're talking… [Laughter] Even when you ask, no" (F13b, female, 2nd clinical year student). Another student added, "It's only when – actually, sometimes they'll tell you to check. I think that's the only way" (F13a, male, 2nd clinical year student). It was not unusual for a faculty member to allow mobile technology use in one situation and restrict it in another as illustrated in the quotes below:

> *But in the clinical training, the practice, it is not good for you, when patients are there, to be using the mobile phone to be checking the dosage of drugs and then the diagnosis. It doesn't instill confidence. And then the people also check on the internet, so you're not different from them. So, we will not encourage them to use it in the clinical practice. They'll use it when they are outside for learning and then for information between them and others. But in the clinical room, they need it to be able to assess data collection and data access, for research and for teaching. But in the theater – well, let me see; even taking pictures, it's better they use the official camera and other things so that they don't take inappropriate*

> *pictures of people in compromising situations. They have medicolegal implications. So, in clinical practice and in the classroom, we'll try to limit or restrict their use" (P16, male, faculty member).*

> *Clinical training is more of – you know it's more of professionalism and then hands-on. I know definitely there are components where they'll be required to maybe use e-libraries and the rest, which – yeah, but aside that; most of the time it's hands-on. So hands-on, you wouldn't use them. (P7, male, faculty member)*

According to a second clinical year student, most of his instructors did not like it when students used their devices in class because they thought that students were looking for mistakes in what was being taught. He said,

> *They would shout on you – some of them will actually shout on you, if they see you with your phone. I mean, thinking you are in an attempt of finding out whether what they are teaching you is sure or not. So, most of them actually feel that we go online to try and find mistakes – and verify every single information. (P10, male, 2nd clinical year student)*

One faculty member, however, was not worried about students pointing out errors to him. He said,

> *And what is amazing is that as you are teaching the students, they are also cross-checking and finding out whether you're teaching them the right thing. So sometimes, you mention the term; they Google to find out whether it's correct or it's wrong. And when you're wrong, sometimes they say, well this is not what it says. Immediately, they prompt you. So that makes you – if you're not prepared, you don't go there. (P5, male, faculty member)*

Faculty members were more welcoming of laptops in the classroom compared to smartphones and tablets. The following quote illustrates how faculty members exercised their social influence on students to restrict mobile technology use in the classroom.

> *So, in class, they have their laptops there, they have internet; just that you have to make sure that you manage the use of them…In the classroom, I think we try to insist. For the laptops, we allow them to use the laptops. I can just – some of them will want to type. But the phones, smartphones, tablets, we try to restrict … (P17, male, faculty member)*

Organizational Factors

Asked whether there were any policies to regulate how mobile technology was used in the educational environment by medical students, staff and faculty members mainly talked about restrictions when it comes to examinations. The following quotes illustrate this:

> *Yes, but you know University of Ghana, and also here, we don't allow these gadgets in exam hall. You have to put it somewhere, more than 30 meters radius away from the exam center. And if you are seen with this gadget in the exam room, the most lenient punishment you get will be to be sacked. (P3, male, faculty member)*

> *Yes, with the pre-clinical, our exams, you're not allowed to bring in any phone of any sort. That one is a foreign material and it's punishable by cancellation of the paper. So, it is too dangerous to allow a student to send them. Even a smart watch is now not allowed. (P7, male, faculty member)*

> *Yeah, currently the policy there is that they can't use mobile phones in the examination hall. For now, we don't allow that. (P1, female, administrator)*

P14 was not aware if his school had policies regarding mobile technology use in the educational environment. When asked, his response was "Not to the best of my knowledge" (P14, male, librarian). P8 described one way in which his university was supporting mobile technology use in the following quote:

> *For policies, I'm not aware of those policies. Just that, the students go for third trimester. They'll go back – on the field. And the university acquired laptops that each group goes with. A laptop from the university for their research work, data collection, typing, report generation and all that. So, I think that is the only thing I can actually confirm the university is doing… (P8, male, IT staff and instructor)*

Asked whether their universities might introduce programs or policies to provide mobile devices such as tablets to incoming students, staff and faculty members had mixed reactions. At UDS-SMHS and UG-SMD, attempts had been made or were being made at adding tablet computers to each incoming student's starter pack. Efforts at UDS-SMHS were unsuccessful while the policy at UG-SMD was awaiting ratification as described in the quotes below:

> *We had an agreement with Vodafone, right now the agreement collapsed. So, they were to supply tablets to the students … Somewhere the deal fell through. It was for both staff and then students. (P7, male, faculty member)*

> *There was a draft policy which is yet to be rectified by council. And that it's going to be mandatory for all freshers [“frosh”] at the point – at the time that this draft will be ratified, every student that comes in will be given a tablet. And then courses will be preloaded as per your admission. And the cost of the tablet will be spread over the cost of your stay in the university. (P2, male, IT manager)*

Institutional and governmental bottlenecks were the main reasons for delays in implementing policies to provide mobile technologies to students. P1 also lamented about how long it took for initiatives approved for the entire university to reach her school. There was also the issue of the relationship between the medical and dental school on one hand, and the teaching hospital (Korle-Bu Teaching Hospital). This issue of bottlenecks is further illustrated in the following quotes:

> *…this school or this university works on committee system. So, for them to take any decision, it has to be tabled, and it'll go through committees and boards to decide on whatever they want. (P1, female, administrator)*

> *Adding it to the starter pack will take a long time because fees are not determined by the school. Now, it has to go to the government for approval. So, anything that will push up the fees, government will want to take it out. (P17, male, faculty member)*

> *… with the collegiate system of governance, it looks like things happen on [main] campus before it gets here. They always forget us here. So, things happen there before it gets here. And again because of the layout of this place, some of the departments for instance, like the clinical departments; they are not linked to the university backbone. They are hooked on Korle-Bu and – and sometimes you know Korle-Bu can be funny. Sometimes they say, we don't want you to be on our thing; sometimes they agree. So, it's a mixture of – mixed feelings – (P1, female, administrator)*

6.4 Attitudes towards m-health use

Use regulation

In general, students, staff and faculty members had a welcoming attitude towards m-health. Most students, staff and faculty members agreed that mobile technology was useful for teaching, learning and patient care, although they pointed out several concerns that needed to be addressed to ensure its effective use. As outlined in the previous sections of this chapter, instructors tended to limit m-health use in specific contexts, to ensure effective teaching and learning. In general, all groups called for regulation of mobile technology use in the learning environment in order to ensure effective use.

Suggestions were put forward to address potential problems such as distraction, inappropriate use, security and cheating in exams. Among them was that devices should be configured in such a way that they cannot be used for any other purpose apart from teaching and learning. The quote below aptly captured this view:

> *So, if these devices are supplied to the students and they're configured in such a way that there's restricted usage only to teaching and learning, then it can enhance the process. But if it's the usual mobile devices that we know, then the downside is inevitable. (P15, male, faculty)*

In addition to not being able to use devices for other purposes, a faculty member was very concerned about system security. He further asserted that:

> *We have to define the system we're going to use and then regulate it well, not just going to use this media, social media things. Regulation is key. And they have to choose professional software… And secondly, you see, using it for assessment; if they've chosen one thing and then they have rules, and then we know that they cannot be manipulated. (P16, male, faculty)*

In summarizing his views about mobile technology use for teaching and learning among clinical year students, he said “Oh, that’s good. Well, I think it’s a good idea. But, as I say, it should be a bit limited.” (P16, male, faculty)

An IT staff was concerned about cheating during exams. According to him, “There should be restrictions to prevent cheating and searching for answers online. There should be a lot of policies on mobile technology use. The policies should include strict punishment for offenders. No mobile phones are allowed in exam halls” (P12, male, IT staff). A second clinical year student expressed similar thoughts as follows:

> *And the final thing, too, would be the fact that there would have to be some kind of ethical code for the students. Because if you try to move exams to information technology and m-health applications or whatever, I mean, obviously, you can cheat. (F13b, male, 2nd clinical year student)*

6.5 Summary of qualitative findings

Laptops, smartphones and tablets were the most frequently mentioned devices during interviews and focus group discussions. Students and instructors used many different apps for different purposes. Whatsapp was pivotal to dissemination of course materials, communication among students and communication between students and instructors. Students and instructors used m-health for teaching and learning, assessment and evaluation, communication and information dissemination, information seeking, information capture and storage, and keeping organized. Students interviewed described themselves as frequent m-health users while most instructors interviewed were limited users. The main benefits were convenience and ease of doing things, saving or maximizing time, interactivity, getting instant feedback and other information, having access to international expertise, and cost-savings. The main drawbacks mentioned were distraction and time wasting, credibility of online information, inappropriate uses, potential for abuse, demotivating knowledge and skill retention by encouraging student laziness. The main facilitating conditions identified by participants during interviews and focus group discussions were availability, quality and reliability of technology, technical support, security, cost, technology competence and training, portability, task and goal fit, social and organizational factors. Attitudes of students, staff and faculty members towards m-health use in the learning environment were framed around its effectiveness in teaching, learning and assessing patients. Although most of them agreed that mobile technology was useful for teaching, learning and patient care, they called for its use to be regulated to ensure effective teaching and learning.

Chapter 7

7 Discussion

Broadly, this study sought to investigate how clinical year undergraduate medical students in Ghana used mobile technology in the educational context and with what outcomes. In this chapter, main findings from chapters five and six are summarized with respect to this study's research questions. These findings are then discussed in light of existing research while highlighting implications for medical education and health care. Considering the sequential mixed methods approach adopted in this study, findings from the qualitative analysis were used to provide further contextual information and insights into quantitative findings where necessary. Where contrasts existed, these were discussed in light of findings from similar studies.

7.1 Types and uses of information technology and m-health, and contexts in which they are used

Under this research objective, the following research questions were asked: (a) what types of m-health are being used by clinical year undergraduate medical students for learning and clinical training in Ghana; (b) what activities do clinical year undergraduate medical students in Ghana use m-health for; (c) how do clinical year undergraduate medical students in Ghana find out about new m-health technologies; and (d) does the frequency of m-health use depend on the learning context?

None of the schools included in this study provided devices to students, so students brought whichever devices that they could acquire and that would enable their effective learning. In general, students used technologies—devices, apps and programs—that were affordable, beneficial to their learning goals and suited their learning contexts.

Most students reported having used m-health at some point in their medical education. Laptop computers were the most owned devices, followed by smartphones, cellular phones and tablet computers. Compared to students in the United Kingdom surveyed by Payne et al. (2012), the proportion of students with smartphones was smaller. Almost four-fifths of students in that study owned a smartphone, while in this study, two-thirds of students owned one. The majority of students in this study owned three or less devices. It is quite common for people to have both a smartphone and a cellular phone or multiples of either, in Ghana. They do this in order to take advantage of cheaper call, text or internet rates offered by different network companies.

Despite the popularity of laptop computers, students used other mobile technologies in place of laptop computers. Although this study did not dig into the specific contexts in which this happened, information gathered from the interviews point to the fact that students sometimes needed to access information very quickly, and this was done more easily on smartphones because of their portability. As anyone would have expected, students who owned desktop computers used them more frequently than those who did not own any. Although only about a third of students owned desktop computers, about twice that proportion indicated that they had access to them. One would have expected every student to indicate having access to a desktop computer because each school has computer labs and libraries that provide desktop computers for student use. It seems that those who indicated not having access to desktop computers probably never had a need to seek one out because they used mobile devices such as laptops, tablets and smartphones in place of desktops depending on the context. Ellaway et al. (2014) found that medical students did not replace laptop computers completely with mobile technology. Instead, they used those devices in ways that were complementary.

Android, followed by Windows, then iOS were the most common operating systems running on students' devices. There seemed to have been under-reporting of laptop operating systems because when the common laptop operating systems were combined (Windows, MacOS, Linux, Google Chrome), it only accounted for a little more than half of the number of laptops reported. With increasing innovation, there are many tablets with detachable keyboards that are sold as 2-in-1 laptops on the market. Android may indeed account for the shortfall. Android was six times more common than iOS and this was also reflected in their frequencies of use. This contrasts sharply with findings of Payne et al. (2012), who reported that more than half of the medical students they surveyed owned an iPhone. The popularity of Android among students is likely because there is a wide range of Android phone brands, which are significantly cheaper than iPhones.

A personal data plan was the most commonly used source of internet, with students spending GHS10.00 – GHS 19.99 (CAD 2.80 – CAD 5.60) on a personal data plan/package per month. This afforded them 300MB – 1.5BG of data depending on which networks they were on. Although almost half of the students surveyed used WI-FI provided at school, only a tiny proportion of them indicated that it was their most frequently used source of internet. Lack of resources and organizational bottlenecks between school and hospital administrations were cited as being partly responsible for limited WI-FI coverage for clinical year students in teaching hospital settings. With a good proportion of students living off campus, one could guess that a significant amount of individual or group studies would take place there, out of reach of school WI-FI coverage.

Most students—almost 80 percent of respondents—learned about new m-health technologies from their colleagues. Furthermore, more than 70 percent of respondents said they found out about new technologies by searching online. The next most frequently cited source of information about new technologies was from instructors, reported by about 40 percent of respondents. This is interesting in settings where there are no existing institutional programs that incorporate m-health into teaching and learning because it shows that instructors are responsive to the learning needs of students—a sign of their attitudes towards m-health use in teaching and learning. The comparatively low proportion of students that mentioned finding out about new technologies from instructors is not very surprising for a couple of reasons. First, students and some faculty members identified a generational gap in technology use between senior faculty members and younger ones or students. While some of these instructors were not technologically inclined, others were simply not aware of existing technologies and how they could be useful to teaching and learning. Second, many of the faculty members interviewed, including those that actively used m-health for teaching and assessment expressed concern about its distractive nature. Therefore, they made constant efforts to restrict its use especially in the classroom. This was evidenced in the significantly less frequent use of m-health in the classroom and in clinical settings, compared to its use during individual or group studies.

M-health use status was found to be associated with schools. The school with the largest proportion of m-health users was UDS-SMHS (84.4%), followed by UCC-SMS (76.8%) and lastly, UG-SMD (63.4%). This could be attributed to different instructional methods and resources available at the different schools. One might expect that in schools where students are provided with most of the course materials or reference is made mostly to text books, students might not have a need to search for additional information online. On the other hand, one might expect that in schools where teaching involves a lot of reference to current research or where students are not provided with a lot of course materials, students might need to search for a lot of information online.

M-health use frequency depended on the learning context. Students used m-health more frequently during individual or group studies compared to during classes or clinical sessions. Median use frequencies were as follows: classroom – “about half the time,” individual or group studies – “most of the time”, and clinical sessions – “about half the time”. This echoes findings by Ellaway et al. (2014) that students used mobile technology in learning in ways that suited their locations and needs. Furthermore, they found that clinical year students used mobile technology for learning more frequently than pre-clinical year students, while use for personal learning exceeded that in the classroom. The main difference between the two studies is that, while some instructors in this study restricted smartphone use, instructors in the study by Ellaway et al. (2014), did not restrict use.

In the classroom and during clinical sessions, m-health use frequency was related to school. Students at UCC-SMS and UDS-SMHS used m-health more frequently than in the classroom and during clinical sessions than students at UG-SMD. This suggests that instructors at UCC-SMS and UDS-SMHS were probably less restricting of m-health use in class and in the clinical setting compared to those at UG-SMD. This possible explanation is based on the assumption that students in all the schools are equally aware of m-health. Frequency of m-health use during individual or group studies was associated with gender. Although medians and modes for females and males were the same, an examination of mean ranks from a Kruskal Wallis test of equality of proportions test indicated that females used m-health more frequently than males during individual or group studies. This makes sense in light of work by Achampong and Pereko (2010) who found that more female medical students used the internet than males at a medical school in Ghana. Considering that most of the activities performed using m-health by students were internet-dependent, for example, searching and retrieving information and communication, it is not surprising that female medical students would more frequent users of m-health.

The most frequent activities performed by students were communicating with colleagues and accessing social media. Tran et al. (2014) found that about 86 percent of medical students in their study used their smartphones for communicating patient-related information with colleagues. In this study, students communicated much more than patient-related information. Whatsapp was probably central to this because each clinical year cohort had its own Whatsapp group, and some clinical rotations also had their own

Whatsapp groups. In fact, in preparing to administer the survey to students, an administrator advised that sending it to the students via Whatsapp would be more effective than emails, hence she used that medium. Faculty members and staff shared similar views, recounting how effective it is when it comes to sharing lecture slides and other course materials. Facing a sudden power outage, one faculty member quickly shared his lecture slides on Whatsapp and was able to teach while students followed on their mobile devices in class.

Students mostly accessed images, videos and indexed or searchable text content. They used a wide range of apps and websites, including discussion forums and other social media to aid their learning. The most common apps and websites were those that aided in clinical decision-making such as Medscape, Daily Rounds, WebMD, Prognosis, Epocrates and Clinical Cases. These apps generally include clinical case descriptions, a drug database and a community of doctors, nurses and students in the health professions. In a similar fashion, Davies et al. (2012) found that finding information in a timely manner was among the greatest uses of PDAs among medical students. They mostly referred to the British National Formulary (BNF) and the Oxford Handbook of Clinical Medicine (OHCM). Apps and websites that offered instructional material and practice exams or quizzes were also popular among students in this study. Although each school surveyed was a member of the Open Education Resources (OER) collaborative, less than a quarter of students used these resources. However, students actively sought out images, videos and other searchable information online to augment what they received from their instructors. Visualizing concepts and conditions were among the main uses highlighted in focus group discussions and interviews with students and instructors.

These findings confirm students' needs to visualize disease symptoms and medical procedures, find and confirm information, and obtain guidance from experts. The implication of these findings is that any efforts at formalizing mobile learning in health professional education should cater for these needs. Although this study was in a context where students brought in their own devices, and resorted to using apps, website and other resources of their choosing, Ellaway et al. (2014) found that in a setting where students were provided devices by their schools, there was still a lot of flexibility and variability regarding use. According to them, learners used mobile technology in different ways; ways that suited them individually, suited their learning contexts and that would provide them benefit in terms of their learning.

7.2 Impact of m-health (benefits and drawbacks)

In order to assess the impact of m-health, the following research questions were formulated: (a) what are the benefits of using m-health for learning and clinical training among clinical year undergraduate medical students in Ghana; and (b) what are the drawbacks of using m-health for leaning and clinical training among clinical year undergraduate medical students in Ghana?

M-health use was significantly associated with several benefits for students, as shown by findings from the survey, interviews and focus group discussions. Most students agreed that m-learning helped them improve their knowledge, skills and efficiency at various levels of learning, from basic science to clinical skills. It helped them stay more engaged in class and by the patient side. This included asking questions and offering their ideas to instructors and colleagues. M-health also helped them to confirm what they already knew and to access new knowledge. Some faculty members were wary of students crosschecking what they were being taught so they tended to restrict them from using m-health in the classroom. Most students also indicated that m-health helped them to apply what they had learned in class to the clinical setting and in the long run improve patient care. Lastly, m-health also helped students to stay organized. These findings confirm those by Tran et al. (2014) who found that most medical students reported that mobile technology helped to make clinical work more efficient and helped improve patient care.

The main drawbacks were distraction and time wasting resulting from that, uncertainty about credibility of online information, potential for inappropriate uses that impinged on ethics and professionalism, potential for cheating and demotivating knowledge and skill retention by encouraging student laziness. Students, staff and faculty members admitted that using mobile technology when teaching is going on can be distracting and affect a student's learning experience. Furthermore, during personal studies, the temptation to use social media was high and one could be drawn into several minutes of non-academic use at the expense of one's studies. Students need to develop ways of balancing their use of mobile technology for learning with other social and personal uses to make mobile learning effective, while not taking away from important social interactions that many millennials are used to performing online. Uncertainty about the credibility of online information also came up as one of the major drawbacks of m-health. With many websites and social media channels springing up daily, it is difficult to tell which ones provide up-to-date trustworthy information. Coupled with this is the proliferation of predatory journals that publish articles without peer-review for fees. At UCC-SMS one faculty member teaches students how to search for credible literature online. It will be very useful for other schools to follow suit if they do not already have similar courses. Furthermore, it might be helpful for schools to publish a blacklist of websites, apps and journals that students should avoid. Another drawback that came up was the potential to use m-health inappropriately, such as taking selfies with patients or cadavers or taking photos of patients without consent or protecting their identities. This can be prevented if schools publish guidelines for appropriate mobile technology use and make it obligatory for all students to take an e-learning course on appropriate mobile technology use. In regard to the potential for cheating if exams and quizzes were held on mobile platforms, the design of such assessment tests can help to avert this as one faculty member at UDS-SMHS had demonstrated. Furthermore, with a secure learning management system the likelihood of going around the system will be minimized. While most students somewhat or strongly disagreed in the survey that m-health demotivates knowledge and skill retention, a couple of students and a faculty member argued during a focus group discussion and interviews that there was a real threat that students might not be motivated to learn comprehensively and apply that knowledge, but might focus on ways to find quick answers, as provided by their mobile technologies. Students might not be motivated to attend classes and hence might miss out on some aspects of the teaching and learning experience. This can be averted by designing assessments to test not only the breadth of knowledge and skills but the depth as well. Knowing that this is how they will be assessed, students will be motivated to undertake deep learning to acquire the necessary knowledge and skills to make them good doctors.

Despite all the drawbacks discussed above, mobile technology can be said to be generally beneficial to medical students. The main implication of these findings is that if medical schools embrace mobile learning and fully support it, more students are likely to experience the benefits described above and perhaps more.

7.3 Facilitating conditions (enablers and barriers) for m-health use

To assess what enablers and barriers were associated with m-health use, the following research questions were constructed: (a) what enablers are associated with m-health use by clinical year undergraduate medical students in Ghana; (b) what barriers are associated with m-health use by clinical year undergraduate medical students in Ghana; (c) what are the effects of significant social members/connections on m-health use by clinical year medical students in Ghana; and (d) how do clinical year undergraduate medical students in Ghana cope with barriers of m-health use for learning and clinical training?

Students’ responses regarding internet reliability did not go one way. Considering that majority of students used personal data plans most of the time, were located in different parts of the country and had freedom to choose service providers of their preference, it is expectable that their responses regarding internet reliability would be diverse. However, one sure thing is that without reliable internet, m-health use will be greatly constrained. When it came to internet speed, students tended to feel that it was not adequate for their needs. Power supply on the other hand was different. Students tended to feel that it was adequate for their m-health needs. Achampong (2012) identified among other things, power supply and internet connectivity as important factors to consider for the success of health informatics projects in Ghana. As one faculty member noted, 4G internet service is available as far as northern Ghana, contrary to widespread belief. Students switched between school WI-FI and personal data packages depending on their locations, and to suit their needs. At the time of the study, power supply across the country was stable, unlike a few years earlier when there was a nationwide power rationing program due to erratic natural gas supply, low water levels at hydroelectric dams and technical problems at some thermal power generation facilities. The implication of having reliable electricity and internet service go beyond end-users. This environment is conducive for the establishment and growth of technology companies, of which digital health is a part. Indeed, Google recently announced the establishment of an artificial intelligence lab in Accra, Ghana, which now boasts of internet speeds comparable to those in California, USA (Asemota, 2018). Among others, a strong backbone of academic institutions and infrastructure were significant factors in this decision by Google, according to the author.

Price is an important factor in determining access to m-health technology, although absolute price alone may not enough to determine access. The value and benefits associated with using the technology will play a role as well. Students generally were on the fence regarding the price value of m-health. Their median responses to statements that (1) m-health technology is reasonably priced, (2) m-health technology is a fair value for the money, and (3) at the current price, m-health technology provides a fair value were each “neutral/don’t know.” Modal response for the first statement however was “somewhat disagree,” while that for the remining two were each “neutral/don’t know.” The main expenses associated with m-health that emerged from interviews and focus group discussions come from acquiring very good devices, very good apps and good data plans to enable use. Some faculty and staff were of the view that m-health offered cost-savings in terms of stationery costs for information dissemination and the relative price of mobile devices compared to fixed IT systems.

Difficulty in viewing content on a small screen came up as a significant barrier to m-health use. A significantly larger number of students in this study compared to the study by Scott et al. (2017) agreed that this constrained their use. Although tablet computers have the advantage of larger screens, they might be less portable and more conspicuous to use, especially in settings where there is no formal use culture. In the study by Ellaway et al. (2014), where students were provided with iPhones or iPads, some students complained about the small screen sizes of their iPhones while others complained that their iPads were too large, with each group preferring the other group’s device. Perhaps there might be context-specific reasons for these complaints. Further studies comparing the utility of tablet computers to smartphones among the study population in Ghana can help determine which one is preferable in each specific context.

Social influence played a significant role in determining m-health use. From the interviews and survey, it was clear that most students, faculty members and staff felt that m-learning was beneficial to students, although it needed to be used at the appropriate place and time. As such, most instructors made conscious efforts to regulate m-health use in classroom and clinical contexts. Modal responses to the following statements about social influence were each "neutral/don't know" (1) people who are important to me (e.g. tutors, colleagues, patients, carers) think that I should use m-health technology (median: "somewhat agree"), (2) people who influence my behavior think that I should use m-health technology (median: "neutral/don't know"), (3) people whose opinions that I value prefer that I use m-health technology (median: "neutral/don't know"). These findings suggest a lack of certainty about the acceptability of m-health use in the educational setting (both classroom and clinical settings) in general. Indeed, students' uncertainty about instructors', patients' and caregivers' reactions to m-health use in the clinical setting limited their m-health use (median responses: "neutral/don't know"). Consequently, students were more likely to use m-health around house officers, residents or clinical instructors who asked them to Google for information at one point or the other, as told during interviews and focus group discussions. This corroborates findings by Ellaway et al. (2014), Michalec (2012) and Scott et al., (2017) that there are hidden socio-cultural norms regarding mobile technology use in learning, which is not written out in policies or guidelines but enacted, in this context, by instructors, house officers and residents, which perpetuates the power structures organized around seniority.

Technological competence and training emerged from interviews and focus group discussions as an important facilitating condition for m-health use. Four faculty members and two students described how some faculty members are not very knowledgeable when it comes to ICT. However, there was a general consensus that the current generation of medical students were very technologically savvy and were always on their phone. Aggarwal et al. (2015) found that people with low actual IT knowledge were more likely to discontinue technology use after adoption. In view of this, it is important that schools provided regular IT workshops for their instructors and provide drop-in services for students and instructors who need help with performing specific tasks using IT. An IT person and instructor at UDS-SMHS told of how his unit provides training and technical support to faculty members to enable them securely and successfully use IT in teaching. This is a step in the right direction if the other schools are not doing that already, it will be useful if they did.

When faced with technical problems, students mostly relied on their colleagues for assistance or tried to troubleshoot by themselves. Less than a quarter of students reported seeking support from school IT support personnel. This might be because technologically inclined students were more readily available compared to IT support personnel, in a context where students did not have much time, as Ellaway et al. (2014) found. When it comes to learning how to use a device or app, students might best learn from each other through already existing channels of face-to-face interaction or Whatsapp groups. However, when it comes to technical problems with devices, IT support personnel would be the best people to approach, although some schools might argue that being personal devices and of wide variety in a “bring your own device” setting, schools are not obliged to provide technical support. If, however, schools decide to introduce formal mobile learning initiatives, then there will be a stronger case for IT departments to provide technical support for students’ and instructors’ devices.

7.4 Technology adoption and use

Technology adoption and use were assessed using the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). As an explanatory and predictive framework, UTAUT2 was determined to be suitable for answering the following research questions: (a) what factors predict and explain intention to use m-health; and (b) what factors predict and explain existing m-health use? The contribution of each factor towards the two main outcomes in the model, namely behavioural intention to use and actual use of m-health, were calculated using partial least squares (PLS) regression. This enabled a more holistic look at the effects of each factor in the presence of other factors in a multi-level pathway model, in the presence and absence of moderators, namely, age, gender and experience. For the model, Use was measured in terms of how frequently students used m-health in different contexts, and how frequently they used various m-health features or applications.

Intention to use m-health in future was inversely associated with existing use. This means that students who used m-health less frequently had stronger intentions to use m-health in future both in the presence and absence of age, gender and experience. This makes sense because these students probably experienced many of the benefits that m-health provides.

Students found using m-health to be pleasurable. This is probably one of the most important factors that gets new users wanting to use m-health again. Hedonic motivation (HM)—fun and enjoyment associated with m-health use—was significantly associated with intention to use in the direct effects model (at $p < 0.1$) and moderated effects model (at $p < 0.01$). This means that in the presence of gender, age and experience, students who enjoyed using m-health were more had stronger intentions to use it in future. However, since HM was not significantly associated with Use, it is safe to say that how much fun users had with m-health did not determine how frequently they used it.

Habit was significantly associated with m-health use in both the direct and moderated effects models ($p < 0.05$). Habit has been shown to be an important factor in situations of technology use beyond initial exposure and acceptance (Venkatesh et al. 2012, p. 161). Habit—the extent to which students used m-health automatically—had a direct negative association with Use. This means that students who had developed strong habits used m-health less frequently. The inverse relationship between Habit and Use may be attributed to changing learning contexts. Second clinical year students at UDS were attending the first lecture of their new rotation, while third year students were on a break at the time of survey administration therefore at the time of questionnaire administration, they were not frequent users although many of them might have developed the habit of using m-health. Furthermore, with a recent rotation, it might take time for students to gauge the extent to which they can use mobile technologies in the classroom and in the clinical setting. As such, while some students may have developed the habit of using m-health, the frequency of use at the time of the survey was probably low.

The association between Hedonic Motivation and Habit on one hand and Behavioral Intention and Use on the other respectively, has implications for mobile technology adoption among the study population when they become practitioners. Of course, as practitioners, demands on their skills and time will be quite different from that as students. However, as a generation that is not only used to mobile technology and multitasking, but enjoys using them, one would not expect using m-health as a practitioner to be a huge hurdle.

7.5 Attitudes towards m-health use

Assessment of attitudes towards m-health use was conducted based on the following research questions: (a) what are the attitudes of clinical year undergraduate medical students in Ghana, towards the use of m-health technology in learning and providing care; (b) what are the attitudes of key institutional staff members towards the use of m-health by clinical year undergraduate medical students in Ghana; and (c) what are the attitudes of faculty members towards the use of m-health by clinical year undergraduate medical students in Ghana?

Attitudes of students, staff and faculty members towards students use of m-health was largely framed in terms of its effectiveness in facilitating teaching and learning. Most respondents agreed that to achieve effective teaching and learning, m-health use needed to be regulated to suit specific contexts. Most schools only had policies about mobile phone possession during exams. Some instructors gave additional regulations at the beginning of or during their courses.

Although faculty members and staff agreed that mobile learning could be beneficial for students, responses were mixed regarding the use of mobile technology in the classroom, clinical setting or for assessments (quizzes and exams). In the classroom, the main concern raised was distraction. Many students agreed that using mobile technology, especially smartphones, could be distracting during classes and clinical sessions, and not during individual or group studies. The main concerns raised regarding m-health use during clinical sessions and assessments were potential abuses and appropriateness of use. Some clinical instructors felt that using smartphones in the presence of patients to search for information was unprofessional and would create a lack of confidence in the future doctor. Although one faculty member had successfully used mobile technology for assessment a few times, many students, faculty and staff were more skeptical about using mobile technology for assessments because of the risk of cheating. Furthermore, if it was going to be used for assessments, it would only work for some types of assessments, for example, assignments and multiple-choice exams. In general, students and their instructors were aware of the ethical issues associated with using m-health during interactions with patients, such as protection of patient privacy and confidentiality.

Most students were not concerned about other students using m-health during individual or group studies or during patient care. Opinions regarding its use in the classroom and clinical setting were however divided. The median and modal responses to the statement "I have concerns about other students using m-health in the classroom" were each "neutral/don't know," suggesting that students were not sure. This might be because of restrictions put in place by their instructors. However, the median and modal responses regarding having concern about the use of m-health by colleagues for patient care was "somewhat disagree." House officers, residents and some clinical tutors were seen to be more open to m-health use in the clinical setting especially when it came to documenting rare conditions. Thus, in a way, it seemed more culturally acceptable to use a smartphone or tablet computer in that setting compared to in the classroom.

Most staff and faculty members interviewed were welcoming of the idea of introducing m-learning into the curriculum involving the provision of devices to students; two schools were already in the process of doing so. Respondents, however lamented about institutional and government bottlenecks that serve as barriers to a speedy actualization. First, in order to have the support of key decision-makers, awareness needs to be created among them, backed by supporting data that show the effectiveness of similar initiatives. These key decision-makers include deans, heads of department, registrars, academic committee members and university councils. Second, being publicly funded, fees are regulated by government, so any initiative that might cause fees to increase significantly will have to receive clearance from government. Deans and vice-chancellors will need to convince the Minister of Education of the benefits that such an initiative will bring.

Chapter 8

8 Summary, conclusions & recommendations

8.1 Summary & conclusions

The purpose of this study was to investigate how undergraduate clinical year medical students in Ghana used m-health and with what outcomes. Survey questionnaires (online and paper-based) were administered to clinical year students in four medical schools, namely Kwame Nkrumah University of Science and Technology School of Medical Sciences (KNUST-SMS), University of Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine and Health Sciences (UDS-SMHS) and University of Ghana School of Medicine and Dentistry (UG-SMD). A total of 286 returned questionnaires were analyzed in this study. Data from KNUST-SMS were excluded from the first part of the quantitative analysis due to the sample size (n = 5) being too small to enable meaningful comparisons between schools. To further elaborate on findings from questionnaires, two focus group discussions were held with students in groups of four and three. In addition to this, one-on-one interviews were held with three more students. Interviews were conducted for twelve faculty and relevant staff members to elicit their perspectives on m-health use by students. Interviews and focus group discussions were analyzed thematically.

Students were very open to digitally mediated learning, specifically, that involved mobile technologies. Although none of the schools studied had m-health formally instituted into their curricula, a few instructors used it in teaching. Students learned from their seniors that they could not survive without mobile technologies, as such, most students acquired mainly laptops, smartphones and/or tablets. M-health use status was associated with schools, with the largest proportion of m-health users occurring at UDS-SMHS, followed by UCC-SMS and lastly, UG-SMD. Frequency of m-health use was context-dependent. Students used m-health more frequently during individual or group studies compared to the classroom or during clinical sessions. Frequencies of m-health use during clinical sessions were associated with schools that students were enrolled in; students at UCC-SMS used m-health more frequently during clinical sessions than students at UDS-SMHS or UCC-SMS. Frequency of m-health use during individual or group studies was associated with gender. Females used m-health more frequently than males during individual or group studies. Based on the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), students who used m-health less frequently had stronger intentions to use it in future both in the presence and absence of age, gender and experience. Students who had developed a habit of using m-health used it less frequently, perhaps because their learning needs and contexts had changed at the time of this study. Furthermore, students who enjoyed using m-health intended to use it more in future. Students who used m-health less had stronger intentions to use it in future.

M-health helped students participate better in lessons and improve their knowledge, skills and efficiency in various contexts through better communication, information seeking and information dissemination. The generation of students involved in this study were used to and enjoyed using mobile technology in learning and clinical training, although some instructors tended to restrict how students used these technologies depending on the context. As such, m-health use frequency differed between the classroom, clinical setting and individual or group studies. Instructors regulated m-health use in ways that they felt would ensure effective teaching and learning. Despite these benefits, m-health had its drawbacks. The main drawbacks were distraction and time wasting, uncertainty about credibility of online information, inappropriate uses that impinged on ethics and professionalism, potential for cheating and demotivating knowledge and skill retention by encouraging student laziness. The main facilitating conditions for m-health use were availability, quality and reliability of devices and services, technical support, security, cost, technology competence and training, portability, task and goal fit, social and organizational factors. M-health use was constrained by uncertainty about instructors', patients' and caregivers' reactions.

Institutional drive and support by way of policies, guidelines, training for instructors, students and relevant staff, and availability of technological services and technical support, could help to ensure that m-health is used to attain effective teaching and learning in medical schools in Ghana. Being future doctors, medical students' successful adoption and appropriate use of m-health while in school can help ensure that m-health is used effectively and ethically later on in professional practice.

7.2 Recommendations

Considering the numerous benefits that students have indicated gaining from m-health use, medical schools in Ghana are encouraged to explore mobile learning with the aim of incorporating m-health into their curricula. Most students surveyed were already using m-health and this was being constrained by the lack of certainty about its acceptability in the eyes of instructors, health professionals, patients and caregivers. The case for including m-health in curricula is made stronger by the finding that two-thirds of non-users indicated that they would use m-health if it was included in their curricula. With this, more students will be positioned to gain the benefits of using m-health. Students can be provided smartphones or tablet computers at the beginning of their programs and the cost spread over the time of their studies. Spreading the cost over students' study period will ease the burden of upfront costs that comes with acquiring devices. These devices should be restricted for learning and teaching to help cut out distraction.

Second, in order to reduce the impact of the hidden socio-cultural norms, where students are unsure about when or where it is appropriate to use mobile technology, it is important for schools to develop and make accessible, guidelines and policies regarding mobile technology use for both students and their instructors. These guidelines and policies should also ensure that mobile technologies are used appropriately and do not violate patients' respect and privacy. Furthermore, these guidelines and policies should ensure that m-health is used in ways that are not counter-productive to the teaching and learning effort such as not facilitating exam malpractice and not being distracting to users and those around them.

Third, considering the generational gap in technology acceptance and competence identified in this study, awareness needs to be created among instructors about the benefits and challenges of mobile learning. Furthermore, training workshops and continuous support need to be provided to instructors on virtual learning and course design involving mobile technology. Instructors need to design their courses to involve the use of preloaded apps and documents and resource websites such as OER. An online portal containing resources to facilitate such course design and delivery will be very helpful in this regard.

Fourth, to overcome the problem of how to find trustworthy information, all medical programs should include a course on information seeking and appraisal. Such a course should teach students how to determine if an information source is credible and how to use that information. Furthermore, schools can have a portal on their websites where they display a list of blacklisted journals, websites and apps to steer students away.

Fifth, IT directorates and departments need to be staffed and equipped to provide accessible, high quality and reliable technical services such as internet and technical support to students and instructors to ensure smooth use of mobile technology in teaching and learning. Perhaps technical assistance could be available via similar mobile means such as Whatsapp groups. Internet speed will need to be consistently fast and Wi-Fi coverage will need to be expanded beyond faculty buildings. This study acknowledges ongoing projects to improve internet service at various schools, and also acknowledges training and technical support already being provided in each of the schools involved in this study. However, it is important to note that once mobile learning becomes institutionalized, there is likely to be more demand on IT services, therefore IT directorates and departments need to plan for this. In addition to staffing, IT directorates and departments will need to appraise and acquire equipment and software (e.g. learning management platform and security software).

8.3 Contributions of the study

First, this study is very timely because the health technology environment is ripe for the wide-scale deployment of e-health and m-health solutions in Ghana. Smartphone penetration in Ghana is currently at its peak and most medical students are millennials, who grew up at a time when cellular phones and smartphones became ubiquitous. As students interviewed in this study indicated, their generation is more used to mobile technology, social media and the online culture. At the same time, the mobile phone has become the norm for accessing many services such as mobile banking, e-commerce, transportation and delivery in Africa, of which Ghana is no exception. Furthermore, with a national data protection act (Data Protection Act, 2012 (Act 843), 2012), the Ghana E-health Strategy (National Information Technology Agency, 2010), and strong interest by technology giants to establish operations in Ghana (Asemota, 2018), grounds are ripe for e-health to take off, whether driven by government or the private sector. Indeed, in June 2018, the first telemedicine licence in Ghana was issued to BIMA, a company that pioneered mobile health insurance in the country in 2010 (BIMA, 2018). The company now provides health consultation via phone call.

Second, this study contributes empirical evidence from the Ghanaian context regarding m-health adoption and use in medical education. This evidence will contribute to theory regarding factors that influence m-health adoption and use among medical students in a developing country context. To the best of my knowledge, this is the first study of its kind using quantitative and qualitative methods backed by the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) in Ghana involving multiple medical schools. Previous studies have looked at computer skills of medical students in a single medical school (Achampong & Pereko, 2010) or how health professionals and the public in a rural setting in Ghana used mobile technology in accessing health information (Aryee, 2014).

Third, knowledge generated from this study might be useful in aiding in the development of effective modes of introduction of e-health and m-health into medical curricula, as well as medical practice. One such piece of knowledge is that students who enjoyed using m-health intended to use it more in future. Therefore, knowing what aspects of m-health or mobile learning medical students enjoy and benefit from will be helpful when developing m-health solutions for medical students and health professionals in Ghana.

8.4 Study limitations

This study was saddled with a number of limitations. First, owing to the limited amount of time I had in the field (about five months), most of which was consumed by the long process of obtaining ethics and institutional approvals from the study sites, data collection took place at times when some students were not available. At KNUST for example, ethics approval was obtained on the last day of work prior to the university's regular Christmas and new year break. As such, the only way to reach students to complete the survey was via SMS text message with the assistance of the university's ICT directorate. Only five respondents were obtained for this school, leading to a huge imbalance in sample sizes between schools. Owing to this, KNUST was excluded from much of the analysis.

Second, due to the same time constraints in the field, I was unable to follow up with m-health non-users to probe further into their reasons for non-use. Although they completed portions of the questionnaire dealing with enablers and barriers, interviews or focus group discussions would have afforded this study richer data regarding this group.

Third, in assessing m-health use in terms of features or functions of mobile technologies, this study modified the options used by Venkatesh et al. (2012) to reflect what is available on today's mobile devices. It would probably have been useful to include a general option of Health/Medical App to cover the broad range of health or medical apps that students might be using, as opposed to specifically mentioning medicines formulary and standard treatment guidelines. In specifying the latter two options, the study tried to accommodate access to those resources via both the device's web browser and app and therefore did not specify whether it was an app, website or downloaded document.

Fourth, the framing of statements in questions 36.1-36.4 of the questionnaire could be understood in two ways. They could be understood in terms of the users' perceptions of their technological abilities in relation to m-health use or in terms of the health care outcome of m-health use. So, the statements about confidence, for example, could be understood as confidence in using the technology or using the technology makes students confident in what they are doing, whether learning or handling patients.

Similarly, competence could be understood as competence in using m-health technology or using the technology makes students feel competent in what they are doing. This study meant it in the first sense, which is why it was placed under the section on attitudes towards m-health use instead of the section on the impact of m-health use. However, the study recognized the possibility that students might have understood the statements differently, therefore data from those questions were excluded from this study.

8.5 Areas of future research

This study has revealed a few areas for further research. First, considering the fact that most students indicated that their m-health use was constrained by the small screen size of smartphones, it makes sense to propose that they use devices with larger screens such as tablet computers. These come in various screen sizes ranging from seven to 12 inches. However, this may be constrained by cost and portability of devices. Indeed, Ellaway et al. (2014) found that many students with iPhones said they preferred to have iPads, while many of those with iPads said they preferred to have iPhones because of portability and screen size issues. Further studies comparing the utility of smartphones to different sizes of tablet computers among this study population will provide very valuable information to researchers, health IT developers and schools. Applying this knowledge will help in ensuring successful m-health adoption in these schools.

Second, considering that students who had fun with and enjoyed using m-health intended to use it in future, it will be worthwhile investigating what specific aspects of m-health they enjoyed. Findings from this study give a hint to this, for example, students talked about how illustrations, animations and videos helped to enrich their learning experience. Furthermore, both students and instructors talked about how easy it was to communicate and share course-related materials mostly using Whatsapp. Investigating what specific apps or features of apps and devices students enjoy the most will provide valuable knowledge to researchers, health IT developers and schools for selection or development of future technologies.

Third, students' intentions to use m-health if encountered in the future work environment give a hint of possible successful adoption of digital health solutions in health care practice among this population. Indeed, their demonstrated ability to use m-health in the clinical setting, coupled with the relationship between habit and hedonic motivation on one hand and behavioral intention and use on the other, give further strength to this hint. Further research into mobile EHR adoption among the study group, house officers, physicians, dentists, nurses, pharmacists and other allied health professionals will be worthwhile.

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Appendices

Appendix A: Letter of Information and Consent - Students

1. Document Title

Letter of Information and Consent – Student Group

2. Study Title

Investigating the use of m-health for learning and clinical training by students in medical and dental schools in Ghana

3. Principal Investigator

Principal Investigator
Dr. Isola S.Y. Ajiferuke
[redacted]
E-mail: [redacted]
Tel.: [redacted]

4. Co-Investigators

Researcher (PhD Student)
Abdul Malik Sulley
[redacted]
E-mail: [redacted]
Tel.: [redacted]

5. Conflict of Interest

The PhD student (researcher) is also a member of staff of University of Ghana School of Medicine and Dentistry (UGSMD). He does not stand to gain any monetary or job benefits from UGSMD based on which way the results of this study turn out.

6. Introduction

You are being invited to participate in this research study about the use of m-health technology in school by medical and dental students because you are a student enrolled in a medical/dental program. M-health refers to mobile information communication technology used for health-related purposes.

7. Why is this study being done?

The purpose of this study is to find out how medical and dental students are using m-health in school and with what outcomes.

8. How many people will take part in this study?

Up to 905 clinical year students are expected to complete the survey questionnaire. Up to 105 clinical year students, faculty members and staff members are expected to participate in focus group discussions. All participants will be drawn from Kwame Nkrumah University of Science and Technology School of Medical Sciences (KNUST-SMS), KNUST Dental School (KNUST-DS), University of Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine (UDS-SM) and University of Ghana School of Medicine and Dentistry (UG-SMD.

9. What are the study procedures?

<u>Questionnaires</u>

You will be provided with a questionnaire via an email link or a paper-based form. The purpose of the questionnaire is to quantify the types, uses, challenges and benefits of technologies being used by clinical year medical and dental students in Ghana. It will also enable the researcher to understand participants' perceptions, attitudes and experiences with m-health. Each questionnaire will take about 5-20 minutes to complete.

The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

Even though you may have provided information on a questionnaire, these responses will not be reviewed by your school administration.

Focus Group

Participants who wish to participate in focus group discussions (FGDs) will be asked to provide their first names, email addresses and phone numbers at the end of this consent document. A focus group is a small group of representative people who are asked to speak about their opinions as part of the research. A moderator will organize the focus group(s). At least two (2) focus group discussions will be held for students per school. An FGD will comprise of between five (5) and eight (8) participants. Each focus group discussion will be about 30-60 minutes in length and will take place at a mutually agreed convenient location.

You will be asked to speak about your experiences with using mobile communication technology in learning and patient care. All FGDs will be audio recorded. A transcript of respective recordings will be made available to participants upon request. Informal conversations will also be included as data.

While the study team will take precautions to protect your confidentiality, we cannot guarantee that other members of the focus group will respect your privacy or keep the discussions of the group confidential.

10. What are the responsibilities of study participants?

Participants are expected to

1. Complete questionnaires to the best of their abilities
2. Respect the privacy of other participants and keep details of FGDs confidential

11. What are the risks and harms of participating in this study?

No identifying information will be collected from participants except those that opt to participate in focus group discussions (FGDs). This information, i.e. first name, email address and phone number, will be kept confidential. It will not be possible to guarantee a breach of privacy will not occur for all aspects of this study. For example, it is not possible to ensure that FGD participants keep discussions confidential. Nonetheless, the researcher will follow all measures outlined in the document in order to minimize any risks to participants

12. **What are the benefits?**

You may not directly benefit from participating in this study beyond possibly gaining awareness of new technologies and methods of instruction and learning. However, information gathered by researchers may be useful in aiding in the development of effective modes of introducing e-health and m-health into medical curricula and healthcare practice in general.

13. **Voluntary Participation**

13.1. Your participation in this study is voluntary. You may decide not to be in this study, or to be in the study now and then change your mind later. You may leave the study at any time without affecting the course of your studies.

13.2. You may refuse to answer any question on the questionnaire you do not want to answer, or not answer a focus group discussion question by saying "pass".

14. **What are the rights of participants (including in the event of a study related injury)?**

You do not waive any legal rights by signing the consent form.

15. **What are the costs to participants?**

Questionnaires will be completed online or on paper forms that will be made readily available to students. Possible costs to participants may include internet charges, if participants choose to complete the online questionnaire without using their schools' internet facilities.

16. **Are participants paid to be in this study?**

You will not be compensated for your participation in this research. Your participation in this study is voluntary

17. **Can participants choose to leave the study?**

17.1. The researcher can exclude you from the study for reasons such as:
  - Not being a clinical year medical or dental student in one of the schools mentioned above.

17.2. If you decide to withdraw from the study, you have the right to request withdrawal of information collected from you. If you wish to have your information removed please let the researcher know.

18. **How will participant's information be kept confidential?**

18.1. Participants who wish to participate in focus group discussions (FGDs) will be asked to provide their first names, email addresses and phone numbers at the end of this consent document to facilitate organizing FGDs.

18.2. Qualified representatives of the following organizations may look at the study data, for quality assurance (to check that the information collected for the study is correct and follows proper laws and guidelines).

- Representatives of the University of Western Ontario Health Sciences Research Ethics Board that oversees the ethical conduct of this study.
- Representatives of research ethics boards in each participating medical/dental school.

18.3. All identifiable information collected during this study will be kept confidential and will not be shared with anyone outside the study unless required by law.

18.4. Participants will not be named in any reports, publications, or presentations that may come from this study. Pseudonyms will be used where direct quotes are being published.

18.5. While the researcher will do his best to protect your information, there is no guarantee that he will be able to do so. The inclusion of your contact information may allow someone to link the data and identify you

18.6. The researcher will keep anonymized data for seven years. Files will be kept on an external hard drive and stored in a locked cabinet in the secure office of the principal investigator. Electronic data will be permanently purged according to institutional guidelines at the time of data destruction. All paper documents will have identifiable information blacked out using a black permanent marker, and then shredded and recycled.

19. **What if Researchers Discover Something about a Research Participant?**

During the study, the researchers may learn something that they didn't expect. For example, the researchers may obtain feedback that may be valuable in improving student learning or patient care. This will be made known to relevant stakeholders such as faculty members or school administrations, for necessary action to be taken.

20. **Whom do participants contact for questions?**

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics [redacted] The REB is a group of people who oversee the ethical conduct of research studies. The HSREB is not part of the study team. Everything that you discuss will be kept confidential.

21. **Consent**

Completing the survey implies consent that this study has been explained to you, any questions you had have been answered and that you are participating in this study voluntarily

CONTACT FOR FOCUS GROUP DISCUSSION

Please check the appropriate box below and initial:

☐ I agree to be contacted for the focus group discussion portion of this study*

**Please provide the following details if you checked the box above*

*First name:*_______________ *Email:*__________________ *Phone #:*_____________

*Signature:*_____________

☐ I do NOT agree to be contacted for focus group discussion portion of this study

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Appendix B: Letter of Information and Consent – Faculty & Staff

1. **Document Title**

Letter of Information and Consent – Faculty Members & Staff Groups

2. **Study Title**

Investigating the use of m-health for learning and clinical training by students in medical and dental schools in Ghana

3. **Principal Investigator**

Principal Investigator
Dr. Isola S.Y. Ajiferuke
[redacted]
E-mail:
Tel.: [redacted]

4. **Co-Investigators**

Researcher (PhD Student)
Abdul Malik Sulley
[redacted]
E-mail: [redacted]
Tel.: [redacted]

5. Conflict of Interest

The PhD student (researcher) is also a member of staff of University of Ghana School of Medicine and Dentistry (UGSMD). He does not stand to gain any monetary or job benefits from UGSMD based on which way the results of this study turn out.

6. Introduction

You are being invited to participate in this research study about the use of m-health technology in school by medical and dental students because you are a faculty or staff member at your school. M-health refers to mobile information communication technology used for health-related purposes.

7. Why is this study being done?

The purpose of this study is to find out how medical and dental students are using m-health in school and with what outcomes.

8. How many people will take part in this study?

Up to 905 clinical year students are expected to complete the survey questionnaire. Up to 105 clinical year students, faculty members and staff members are expected to participate in focus group discussions. All participants will be drawn from Kwame Nkrumah University of Science and Technology School of Medical Sciences (KNUST-SMS), KNUST Dental School (KNUST-DS), University of Cape Coast School of Medical Sciences (UCC-SMS), University of Development Studies School of Medicine (UDS-SM) and University of Ghana School of Medicine and Dentistry (UG-SMD.

9. What are the study procedures?

Focus Group

Participants who wish to participate in focus group discussions (FGDs) will be asked to provide their first names, email addresses and phone numbers at the end of this consent document. A focus group is a small group of representative people who are asked to speak about their opinions as part of the research. A moderator will organize the focus group(s). At least four (4) focus group discussions will be held per school—two (2) for faculty members and two (2) for staff members. An FGD will comprise of between five (5) and eight (8) participants. Each focus group discussion will be about 30-60 minutes in length and will take place at a mutually agreed convenient location.

You will be asked to speak about your thoughts and experiences regarding students using mobile communication technology in learning and patient care. All FGDs will be audio recorded. A transcript of respective recordings will be made available to participants upon request. Informal conversations will also be included as data.

While the study team will take precautions to protect your confidentiality, we cannot guarantee that other members of the focus group will respect your privacy or keep the discussions of the group confidential.

10. **What are the responsibilities of study participants?**

Participants are expected to

1. Complete questionnaires to the best of their abilities
2. Respect the privacy of other participants and keep details of FGDs confidential

11. **What are the risks and harms of participating in this study?**

No identifying information will be collected from participants except those that opt to participate in focus group discussions (FGDs). This information, i.e. first name, email address and phone number, will be kept confidential. It will not be possible to guarantee a breach of privacy will not occur for all aspects of this study. For example, it is not possible to ensure that FGD participants keep discussions confidential. Nonetheless, the researcher will follow all measures outlined in the document in order to minimize any risks to participants

12. **What are the benefits?**

You may not directly benefit from participating in this study beyond possibly gaining awareness of new technologies and methods of instruction and learning. However, information gathered by researchers may be useful in aiding in the development of effective modes of introducing e-health and m-health into medical curricula and healthcare practice in general.

13. **Voluntary Participation**

13.1. Your participation in this study is voluntary. You may decide not to be in this study, or to be in the study now and then change your mind later. You may leave the study at any time without affecting the course of your studies.

13.2. You may refuse to answer any question on the questionnaire you do not want to answer, or not answer a focus group discussion question by saying "pass".

14. **What are the rights of participants (including in the event of a study related injury)?**

You do not waive any legal rights by signing the consent form.

15. **What are the costs to participants?**

There are no anticipated costs to participants of FGDs.

16. **Are participants paid to be in this study?**

You will not be compensated for your participation in this research. Your participation in this study is voluntary

17. **Can participants choose to leave the study?**

If you decide to withdraw from the study, you have the right to request withdrawal of information collected from you. If you wish to have your information removed please let the researcher know.

18. **How will participant's information be kept confidential?**

18.1. Participants who wish to participate in focus group discussions (FGDs) will be asked to provide their first names, email addresses and phone numbers at the end of this consent document to facilitate organizing FGDs.

18.2. Qualified representatives of the following organizations may look at the study data, for quality assurance (to check that the information collected for the study is correct and follows proper laws and guidelines).

- Representatives of the University of Western Ontario Health Sciences

Research Ethics Board that oversees the ethical conduct of this study.

- Representatives of research ethics boards in each participating medical/dental school.

18.3. All identifiable information collected during this study will be kept confidential and will not be shared with anyone outside the study unless required by law.

18.4. Participants will not be named in any reports, publications, or presentations that may come from this study. Pseudonyms will be used where direct quotes are being published.

18.5. While the researcher will do his best to protect your information, there is no guarantee that he will be able to do so. The inclusion of your contact information may allow someone to link the data and identify you

18.6. The researcher will keep anonymized data for seven years. Files will be kept on an external hard drive and stored in a locked cabinet in the secure office of the principal investigator. Electronic data will be permanently purged according to institutional guidelines at the time of data destruction. All paper documents will have identifiable information blacked out using a black permanent marker, and then shredded and recycled.

19. **What if Researchers Discover Something about a Research Participant?**

During the study, the researchers may learn something that they didn't expect. For example, the researchers may obtain feedback that may be valuable in improving student learning or patient care. This will be made known to relevant stakeholders such as faculty members or school administrations, for necessary action to be taken.

20. **Whom do participants contact for questions?**

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics [redacted] The REB is a group of people who oversee the ethical conduct of research studies. The HSREB is not part of the study team. Everything that you discuss will be kept confidential.

21. **Consent**

This study has been explained to me and any questions I had have been answered.
I know that I may leave the study at any time. I agree to take part in this study.

____________________	____________________	____________________
Name	Email Address	Phone Number

____________________	____________________
Signature	Date *(DD-MMM-YYYY)*

My signature means that I have explained the study to the participant signed above. I have answered all questions.

____________________	____________________	____________________
Print Name of Person Obtaining Consent	Signature	Date*(DD-MMM-YYYY)*

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ID# _ _ _

Appendix C: Survey Questionnaire

INVESTIGATING THE USE OF M-HEALTH FOR LEARNING AND CLINICAL TRAINING BY STUDENTS IN MEDICAL AND DENTAL SCHOOLS IN GHANA

Dear Respondent,

The purpose of this research is to find out how students in clinical years of medical and dental education in Ghana, use mobile communication and computing technology for learning and clinical training. This study has the potential of influencing the inclusion of mobile technology into medical and dental curricula in Ghana. This questionnaire is part of my research work towards the award of a PhD degree in Health Information Science from the University of Western Ontario, Canada. You are being contacted because you are enrolled in a medical or dental program in Ghana, and your current level of study involves some clinical work. I would be very grateful if you complete each question to the best of your ability. All information you provide will be held in strict confidence, will not affect your ongoing studies at your institution, and your participation is voluntary.

Abdul Malik Sulley
[redacted]
London, Ontario, Canada N6A 5B9
E-mail: [redacted]
Tel.: [redacted]

Please use the space at the end of the questionnaire to provide additional information if space provided for any question is insufficient.

DEFINITION: M-health refers to mobile information and communication technology used for health-related purposes, such as education and patient care.

Section A: General information

1) Gender ☐ Female ☐ Male
2) Age ________
3) Institution:
    a. Accra College of Medicine
    b. Family Health Medical School
    c. KNUST Dental School (KNUST-DS)
    d. KNUST School of Medical Sciences (KNUST-SMS),
    e. University of Cape Coast School of Medical Sciences (UCC-SMS),
    f. University of Development Studies School of Medicine and Health Sciences (UDS-SMHS)
    g. University of Health and Allied Sciences School of Medicine (UHAS-SM)
    h. University of Ghana School of Medicine and Dentistry (UG-SMD)
4) Program: ☐ Dentistry ☐ Medicine ☐ Medicine (GEMP)
5) Year of study: (please select the best choice that applies)
    ☐ Level 400 ☐ Level 500 ☐ Level 600 ☐ Other (specify) _________________
6) Current healthcare setting
    a. Teaching hospital
    b. Military hospital
    c. Regional/other hospital
    d. Polyclinic
    e. Health centre
    f. Missionary/quasi-government health facility
    g. Private medical centre/clinic
    h. Other ___________________
7) Parent 1/Guardian 1 occupation: ____________________
8) Parent 2/Guardian 2 occupation: ____________________
9) Monthly family income (estimate total):
    a. < GHS 2,000
    b. GHS 2,000 – GHS 4,999
    c. GHS 5,000 – GHS 9,999
    d. GHS 10,000 – GHS 14,999
    e. ≥ GHS 15,000
    f. Prefer not to answer

Section B: Technology access

10) Do you own a desktop computer? ☐ Yes ☐ No
11) Do you have access to a desktop computer? ☐ Yes ☐ No

12) How frequently do you use a desktop computer? Please choose one option.

□ 1 = never □ 2 = sometimes □ 3 = about half the time

□ 4 = most of the time □ 5 = always

13) Do you own a mobile device? Please select all that apply.

a. None
b. Laptop computer
c. Tablet computer
d. Cellular phone
e. iPod (or similar device)
f. Smartphone
g. Smartwatch
h. Smart wristband (including wearable pulse oximeter)
i. Smartphone/wireless/wearable stethoscope
j. Smartphone/wireless/wearable ultrasound device
k. Smartphone/wireless/wearable electrocardiography (ECG) monitor
l. Smartphone/wireless/wearable electroencephalography (EEG) monitors,
m. Smartphone/wireless otoscope
n. Others (please list) ______________________________

14) To what extent do you agree or disagree with the following statements?

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

14.1	I use mobile technologies as substitutes for a desktop computer	1	2	3	4	5
14.2	I use other mobile technologies as substitutes for a laptop computer	1	2	3	4	5

15) What operating system(s) does/do your mobile device(s) use? Please select all that apply

a. I do not have access to mobile information technology
b. Apple iOS
c. Apple MacOS
d. Android
e. Blackberry OS
f. Chrome OS
g. Other Linux OS (e.g. Ubuntu, Elementary OS, Mint, Gentoo, Snappy, Slax)
h. Microsoft Windows
i. Microsoft Windows Mobile
j. Microsoft Windows Phone
k. Others (please list) _____________________

16) What operating system do you use most frequently on your mobile device(s)? Please select only one option.

a. Apple iOS
b. Apple MacOS
c. Android
d. Blackberry OS
e. Chrome OS
f. Other Linux OS (e.g. Ubuntu, Elementary OS, Mint, Gentoo, Snappy, Slax)
g. Microsoft Windows
h. Microsoft Windows Mobile
i. Microsoft Windows Phone
j. Other (please indicate) ____________________

17) How do you access internet for your mobile devices? Please select all that apply.
  a. I do not use the internet
  b. School WI-FI
  c. Other WI-FI
  d. Personal data plan/package
  e. Others (please list) _____________________
18) What is your most frequently use internet source for your mobile devices? Please select only one option.
  a. I do not use the internet
  b. School WI-FI
  c. Other WI-FI
  d. Personal data plan/package
  e. Other (please indicate) _____________________
19) How much money do you spend averagely on a personal data plan/package per month?
  a. None
  b. < GHS 3.00
  c. GHS 3.00 – GHS 9.99
  d. GHS 10.00 – GHS19.99
  e. GHS 20.00 – GHS29.99
  f. GHS 30.00 – GHS39.99
  g. GHS 40.00 – GHS49.99
  h. ≥ GHS 50.00
  i. Prefer not to answer
20) Based on the description of m-health provided above, have you used m-health while in medical/dental school? ☐ Yes ☐ No

If your response is "No" please proceed to questions 32-34, 38-39

Section C: Types of m-health and the contexts within which they are used

21) ***Experience***: For how long have you been using m-health?

a. ≤ 3 months
b. 4 – 6 months
c. 7 – 12 months
d. 1 – 2 years
e. 2 – 3 years
f. ≥ 3 years

22) How do you learn about new m-health technologies? Please select all that apply.

a) Colleagues/peers
b) Tutors/teachers/faculty members
c) School administration
d) Non-academic staff e.g. IT support, library
e) Online
f) Other (please list): ___________________________________

23) How frequently do you use m-health technologies in the following contexts?

[1=never 2=sometimes, 3=about half the time, 4= most of the time, 5= always]

23.1	In the classroom	1	2	3	4	5
23.2	During individual or group studies	1	2	3	4	5
23.3	During clinical sessions or patient care	1	2	3	4	5

24) How frequently do you use the following m-health functions, apps or programs?

[1=never 2=sometimes, 3=about half the time, 4= most of the time, 5=always]

24.1	Phone calling	1	2	3	4	5
24.2	SMS	1	2	3	4	5
24.3	Photo gallery or similar app/program	1	2	3	4	5
24.4	Video player/streaming	1	2	3	4	5
24.5	Web browser	1	2	3	4	5
24.6	Medicines formulary (please specify)	1	2	3	4	5
24.7	Standard treatment guidelines (please specify)________________	1	2	3	4	5
24.8	Other (please specify): ___________________________________	1	2	3	4	5
24.9	Other (please specify): ___________________________________	1	2	3	4	5
24.10	Other (please specify): ___________________________________	1	2	3	4	5
24.11	Other (please specify): ___________________________________	1	2	3	4	5

25) How frequently do you use the following m-health devices?
[1=never 2=sometimes, 3=about half the time, 4= most of the time, 5=always]

25.1	Laptop computer	1	2	3	4	5
25.2	Tablet computer	1	2	3	4	5
25.3	Cellular phone	1	2	3	4	5
25.4	iPod (or similar device)	1	2	3	4	5
25.5	Smartphone	1	2	3	4	5
25.6	Smartwatch	1	2	3	4	5
25.7	Smart wristband (including wearable pulse oximeter)	1	2	3	4	5
25.8	Smartphone/wireless/wearable stethoscope	1	2	3	4	5
25.9	Smartphone/wireless/wearable ultrasound device	1	2	3	4	5
25.10	Smartphone/wireless/wearable electrocardiography (ECG) monitor	1	2	3	4	5
25.11	Smartphone/wireless/wearable electroencephalography (EEG) monitors	1	2	3	4	5
25.12	Smartphone/wireless otoscope	1	2	3	4	5
25.13	Other (please specify): ______________________________________	1	2	3	4	5
25.14	Other (please specify): ______________________________________	1	2	3	4	5
25.15	Other (please specify): ______________________________________	1	2	3	4	5

Section D: Uses of m-health

26) What school-related activities do you mostly use m-health technology to do? Please select all that apply

a. Access medicines formulary (please specify) _____________________________
b. Access standard treatment guidelines (please specify) _____________________
c. Access OER materials from my tutors
d. Access OER materials from other universities
e. Access Free Open Access 'Meducation' (FOAM) resources
f. Access MEDSKL resources
g. Access calendar or "to do" lists or improve timetabling
h. Communicate with colleagues
i. Communicate patient information with colleagues or patients
j. Communicate with tutors
k. Communicate with patients/carers
l. Access social media including media sharing websites
m. Other (please specify): ____
n. Other (please specify): ____
o. Other (please specify): ____

p. Other (please specify): ____

27) What do you mostly use social media for, while in the educational environment? Please select all that apply.

a. I do not use social media
b. Make new friends or connect with old friends
c. Pursue hobbies and extra-curricular interests
d. Access up-to-date school-related information e.g. events, schedules, etc.
e. Exchange academically relevant ideas with colleagues or practitioners
f. Access information about the latest trends in medicine/dentistry
g. Other (please specify): ____
h. Other (please specify): ____
i. Other (please specify): ____
j. Other (please specify): ____

28) What types of content do you prefer accessing via m-health? Please select all that apply.

a. Indexed or searchable text
b. Images
c. Podcasts and other audio
d. Videos
e. Simulations, games or role-play
f. Other (please specify): ____
g. Other (please specify): ____
h. Other (please specify): ____

Section E: Impact of m-health

29) To what extent do you agree or disagree with the following statements?

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

	Performance Expectancy					
29.1	PE1. I find m-health technology useful in my school life.	1	2	3	4	5
29.2	PE3. Using m-health technology helps me accomplish things more quickly.	1	2	3	4	5
29.3	PE4. Using m-health technology increases my productivity.	1	2	3	4	5
	Effort Expectancy					
29.4	EE1. Learning how to use m-health technology is easy for me.	1	2	3	4	5
29.5	EE2. My interaction with m-health technology is clear and understandable.	1	2	3	4	5
29.6	EE3. I find m-health technology easy to use.	1	2	3	4	5

29.7	EE4. It is easy for me to become skillful at using m-health technology.	1	2	3	4	5

30) Benefits of m-health use: To what extent do you agree or disagree with the following statements? Using my m-health technology has enabled me/motivates me to…

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

30.1	Stay more engaged in class or by the patient side	1	2	3	4	5
30.2	Access ideas, concepts and new knowledge	1	2	3	4	5
30.3	Improve my basic science knowledge and skills	1	2	3	4	5
30.4	Improve my clinical knowledge and skills	1	2	3	4	5
30.5	Confirm information I already knew	1	2	3	4	5
30.6	Ask questions of the teacher or my peers	1	2	3	4	5
30.7	Offer my ideas to the teacher or my peers	1	2	3	4	5
30.8	Discuss and debate my ideas with other learners	1	2	3	4	5
30.9	Apply what I have learned to clinical practice	1	2	3	4	5
30.10	Repeatedly practice what I've learned, using feedback that enables me to improve performance	1	2	3	4	5
30.11	Share my practice outputs with peers, for comparison and comment	1	2	3	4	5
30.12	Reflect on my learning experience, by presenting my own ideas, reports, designs (productions) to peers	1	2	3	4	5
30.13	Improve my learning experience	1	2	3	4	5
30.14	Improve efficiency in the clinical environment	1	2	3	4	5
30.15	Improve patient care	1	2	3	4	5
30.16	Other (please specify): ______________________________________	1	2	3	4	5
30.17	Other (please specify): ______________________________________	1	2	3	4	5
30.18	Other (please specify): ______________________________________	1	2	3	4	5

31) Drawbacks of m-health use: To what extent do you agree or disagree with the following statements? Using my m-health technology …

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

31.1	Is distracting/disruptive in the classroom	1	2	3	4	5
31.2	Is distracting/disruptive during individual or group studies	1	2	3	4	5
31.3	Is distracting/disruptive during clinical practice	1	2	3	4	5
31.4	Demotivates knowledge retention	1	2	3	4	5
31.5	Demotivates skill retention	1	2	3	4	5
31.6	Other (please specify): ____________________________________	1	2	3	4	5
31.7	Other (please specify): ____________________________________	1	2	3	4	5
31.8	Other (please specify): ____________________________________	1	2	3	4	5

Section F: Enablers and barriers

32) To what extent do you agree or disagree with the following statements?

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

	Facilitating Conditions					
32.1	FC1. I have the resources necessary to use m-health technology.	1	2	3	4	5
32.2	FC2. I have the knowledge necessary to use m-health technology.	1	2	3	4	5
32.3	FC3. M-health technology is compatible with other technologies I use.	1	2	3	4	5
32.4	FC4. I can get help from others when I have difficulties using m-health technology.	1	2	3	4	5
	Price Value					
32.5	PV1. M-health technology is reasonably priced.	1	2	3	4	5
32.6	PV2. M-health technology is a fair value for the money.	1	2	3	4	5
32.7	PV3. At the current price, m-health technology provides a fair value.	1	2	3	4	5
	Social Influence					
32.8	SI1. People who are important to me (e.g. tutors, colleagues, patients, carers) think that I should use m-health technology.	1	2	3	4	5
32.9	SI2. People who influence my behavior think that I should use m-health technology.	1	2	3	4	5
32.10	SI3. People whose opinions that I value prefer that I use m-health technology.	1	2	3	4	5
	Hedonic Motivation					
32.11	HM1. Using m-health technology is fun.	1	2	3	4	5
32.12	HM2. Using m-health technology is enjoyable.	1	2	3	4	5
32.13	HM3. Using m-health technology is very entertaining.	1	2	3	4	5

33) To what extent do you agree or disagree with the following statements? M-health technology for learning is encouraged/enhanced because …

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

33.1	Internet service is reliable	1	2	3	4	5
33.2	Internet speed is adequate for my needs	1	2	3	4	5
33.3	Power supply is adequate for my m-health needs	1	2	3	4	5
33.4	Other (please specify): ________________________________	1	2	3	4	5
33.5	Other (please specify): ________________________________	1	2	3	4	5
33.6	Other (please specify): ________________________________	1	2	3	4	5

34) To what extent do you agree or disagree with the following statements? M-health technology for learning is constrained/limited because …

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

34.1	I have difficulty viewing content on a small screen	1	2	3	4	5
34.2	I get distracted	1	2	3	4	5
34.3	I am unsure of tutors'/clinicians' reactions	1	2	3	4	5
34.4	I am unsure of patients'/carers' reactions	1	2	3	4	5
34.5	I have multiple devices	1	2	3	4	5
34.6	Mobile learning is not my preferred learning style	1	2	3	4	5
34.7	I have lost/fear losing my device	1	2	3	4	5
34.8	I am unsure about legal implications or consequences	1	2	3	4	5
34.9	I have limited awareness about m-health	1	2	3	4	5
34.10	Other (please specify): ________________________________	1	2	3	4	5
34.11	Other (please specify): ________________________________	1	2	3	4	5
34.12	Other (please specify): ________________________________	1	2	3	4	5

35) Technical support: To what extent do you agree or disagree with the following statements? When I encounter technical problems, I seek assistance from …

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

35.1	Myself	1	2	3	4	5
35.2	Institutional IT support staff	1	2	3	4	5
35.3	Colleagues/peers	1	2	3	4	5
35.4	Family members	1	2	3	4	5
35.5	External/commercial IT services	1	2	3	4	5
35.6	Other (please specify): ________________________________	1	2	3	4	5
35.7	Other (please specify): ________________________________	1	2	3	4	5
35.8	Other (please specify): ________________________________	1	2	3	4	5

Section G: Attitudes towards m-health use

36) To what extent do you agree or disagree with the following statements?

[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

36.1	I feel confident using my m-health for learning	1	2	3	4	5
36.2	I feel confident using my m-health for patient care	1	2	3	4	5
36.3	I feel competent using m-health for learning	1	2	3	4	5
36.4	I feel competent using m-health for patient care	1	2	3	4	5

37) To what extent do you agree or disagree with the following statements?
[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

	Habit					
37.1	HT1. The use of m-health technology has become a habit for me.	1	2	3	4	5
37.2	HT2. I am addicted to using m-health technology.	1	2	3	4	5
37.3	HT3. I must use m-health technology.	1	2	3	4	5
37.4	HT4. Using m-health technology has become natural to me.	1	2	3	4	5

38) To what extent do you agree or disagree with the following statements?
[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

38.1	I have concerns about other students using m-health in the classroom	1	2	3	4	5
38.2	I have concerns about other students using m-health for individual or group studies	1	2	3	4	5
38.3	I have concerns about other students using m-health for patient care	1	2	3	4	5

39) To what extent do you agree or disagree with the following statements?
[1=Strongly agree 2= Somewhat agree, 3=Neutral/don't know, 4=Somewhat disagree, 5=Strongly disagree]

	Behavioral Intention & Use					
39.1	BI1. I intend to continue using m-health technology in the future.	1	2	3	4	5
39.2	BI2. I will always try to use m-health technology in my school life.	1	2	3	4	5
39.3	BI3. I plan to continue to use m-health technology frequently.	1	2	3	4	5
39.4	BI41. I will use m-health if introduced in the school curriculum	1	2	3	4	5
39.5	BI5. I will use m-health for patient care if I encounter it in the work setting.	1	2	3	4	5

Your participation in this study is greatly appreciated. Thank you.

Version 5.3 12/02/2017

Appendix D: Interview/Focus Group Discussion Guide – Students

1) Tell me about the mobile technologies you are using, or have you used while in medical/dental school.
2) What are your impressions/feelings about m-health, including specific ones you may have used?
3) Tell me what you think about using mobile technology for teaching in your school.
4) Tell me what you think about using mobile technology for assessment in your school (e.g. quizzes, exams, assignments).
5) How effective has mobile technology been for your in learning and clinical training?
    a. Tell me about some of the significant outcomes.
    b. How effective has social media been in this regard?
6) What drawbacks/constraints have you experienced?
    a. How did you overcome those constraints?
    b. What are the attitudes of colleagues, tutors and school administration regarding m-health use?

Version 5.2 11/12/2017

Appendix E: Interview schedule – Faculty Members

1) Tell me what you think about using information technology for teaching in your school.
2) Tell me what you think about using mobile technology for teaching in your school.
3) Tell me what you think about using mobile technology for assessment in your school (e.g. quizzes, exams, assignments).
4) Tell me what you think about students using mobile technology for learning, especially in the classroom?
5) Tell me what you think about students using mobile technology for clinical training?

Version 5.2 11/12/2017

Appendix F: Interview schedule – Staff

1) Tell me what you think about using mobile technology for teaching in your school.
2) Tell me what you think about using mobile technology for assessment in your school (e.g. quizzes, exams, assignments).
3) Are there any policies regarding students use of mobile technology for learning?
4) Are there any technology support structures or services for the school community?
5) How likely is your school to include mobile technology in the educational environment?
6) Are there any policies regarding students use of mobile technology for clinical training?

Version 5.2 11/12/2017

Appendix G: Email Script for Recruitment

Subject Line: Invitation to participate in research

Hello,

You are being invited to participate in a study that we, Abdul Malik Sulley (PhD student) and Dr Isola Ajiferuke (Principal Investigator) are conducting. Briefly, the purpose of this study is to find out how clinical year medical and dental students in Ghana, are using m-health in school and with what outcomes. M-health is mobile information communication technology used for health-related purposes.

The study involves completing an online questionnaire at your own convenience. This is expected to take at most 30 minutes of your time. You may opt to participate in a focus group discussion in addition to this. Instructions on how to do so are provided in the letter of information at the beginning of the questionnaire.

Up to four (4) reminder emails may be sent to encourage students to complete the survey questionnaire. These reminders will be sent only if enrolment is poor and will be spaced two weeks apart. If you do not want to be contacted again regarding this study, please reply to this email indicating so.

Participation in this study is voluntary.

If you would like to participate in this study, please click on the link below to access the letter of information and survey link.
https://uwo.eu.qualtrics.com/jfe/form/SV_cvw1ovgVeBN1ZOt

Thank you,

Principal Investigator
Dr. Isola S.Y. Ajiferuke
[redacted]
London, Ontario, Canada N6A 5B9
E-mail: [redacted]
Tel.: [redacted]

<u>Researcher (PhD Student)</u>
Abdul Malik Sulley
[redacted]
London, Ontario, Canada N6A 5B9
E-mail: [redacted]
Tel.: [redacted]

Appendix H: Recruitment SMS & Whatsapp message

Hello,

You are invited to participate in a study on how medical and dental students in Ghana use mobile technology in school.

To take the survey, please follow this link
https://uwo.eu.qualtrics.com/jfe/form/SV_cvw1ovgVeBN1ZOt

Appendix I: Script for Classroom Recruitment

Hello, my name is Abdul Malik Sulley and I am from the Faculty of Information and Media Studies at University of Western Ontario, Canada. I am here today to talk to you about a research study about how clinical year medical and dental students in Ghana use m-health (mobile information communication technology) in learning and clinical training. This study is being done under the supervision of Dr Isola Ajiferuke.

I am currently recruiting participants who are clinical year medical or dental students in Ghana and who would like to participate in this study. Briefly, the study involves completing an online questionnaire at your own convenience. This is expected to take at most, 30 minutes of your time. You may opt to participate in a focus group discussion in addition to this. Instructions on how to do so are provided in the letter of information at the beginning of the questionnaire.

Participation in this study is voluntary.

If you are interested in participating or have any questions; please contact me at the email address / phone number provided.

Thank you for considering participation in this study.

E-mail: [redacted]
Tel.: [redacted]

Version 5.3 12/02/2017

Appendix J: Research Ethics Approval Notices

Western Research

Date: 27 November 2017

To: Isola Ajiferuke

Project ID: 110182

Study Title: M-health in medical and dental schools in Ghana

Application Type: HSREB Initial Application

Review Type: Delegated

Meeting Date / Full Board Reporting Date: 05/Dec/2017

Date Approval Issued: 27/Nov/2017

REB Approval Expiry Date: 27/Nov/2018

Dear Isola Ajiferuke

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Classroom Recruitment Script	Recruitment Materials	15/Oct/2017	
FGD guide Faculty Members - CLEAN	Focus Group(s) Guide	12/Nov/2017	5.2 Clean
FGD guide Staff - CLEAN	Focus Group(s) Guide	12/Nov/2017	5.2 Clean
FGD guide Students - CLEAN	Focus Group(s) Guide	12/Nov/2017	5.2 Clean
LOIC Faculty & Admin v5.3 12.11.17 CLEAN	Written Consent/Assent	12/Nov/2017	5.3 clean
LOIC Students v5.3 12.11.17 CLEAN	Written Consent/Assent	12/Nov/2017	5.3 clean
Questionnaire CLEAN	Paper Survey	22/Oct/2017	5.2
Recruitment Email - Reminder1 CLEAN	Email Script	15/Oct/2017	Clean
Recruitment Email CLEAN	Email Script	15/Oct/2017	Clean
Recruitment Poster CLEAN	Recruitment Materials	12/Nov/2017	Clean

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
1 Proposal - Medical and dental students' use of m-health in Ghana v5.4 11-20-2017 clean	Protocol	20/Nov/2017	5.4 clean
Online survey link	Online Survey	22/Oct/2017	Clean
Profile	Protocol	15/Oct/2017	
Rationale_refs	References	13/Sep/2017	Version 5

No deviations from, or changes to, the protocol or WREM application should be initiated without prior written approval of an appropriate amendment from Western HSREB , except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University HSREB operates in compliance with, and is constituted in accordance with, the requirements of the TriCouncil Policy Statement: Ethical

Page 1 of 2

Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Patricia Sargeant, Ethics Officer on behalf of Dr. Marcelo Kremenchutzky, HSREB Vice-Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Figure A1: Ethics approval from University of Western Ontario

UNIVERSITY OF GHANA
COLLEGE OF HEALTH SCIENCES
ETHICAL AND PROTOCOL REVIEW COMMITTEE

3rd November, 2017.

Ref. No.:..

Dr. Isola S.Y. Ajiferuke
Dept. of Centre for Tropical,
Clinical Pharmacology and Therapeutics
SMD
Korle-Bu,Accra.

ETHICAL CLEARANCE

Protocol Identification Number: **CHS-Et/M.3 – P1.10/2017-2018**

The Ethical and Protocol Review Committee of the College of Health Sciences on the 2nd of November, 2017 unanimously approved your research proposal.

TITLE OF PROTOCOL: **"Investigating the use of M-Health for learning and Clinical practice by student in Medical and Dental School in Ghana"**

PRINCIPAL INVESTIGATOR: **Dr.Isola S.Y. Ajiferuke**

This approval requires that you submit six-monthly review reports of the protocol to the Committee and a final full review to the Ethical and Protocol Review Committee at the completion of the study. The Committee may observe, or cause to be observed, procedures and records of the study during and after implementation.

Please note that any significant modification of this project must be submitted to the Committee for review and approval before its implementation.

You are required to report all serious adverse events related to this study to the Ethical and Protocol Review Committee within seven (7) days verbally and fourteen (14) days in writing.

As part of the review process, it is the Committee's duty to review the ethical aspects of any manuscript that may be produced from this study. You will therefore be required to furnish the Committee with any manuscript for publication.

This ethical clearance is valid till 3rd November, 2018.

Please always quote the protocol identification number in all future correspondence in relation to this protocol.

Signed: ....
PROFESSOR ANDREW A. ADJEI
CHAIRPERSON, ETHICAL AND PROTOCOL REVIEW COMMITTEE

cc: Provost, CHS
Dean, SMD
Head of Department

Figure A2: Ethics approval from College of Health Sciences, University of Ghana

Centre for Tropical Clinical Pharmacology & Therapeutics

7th November 2017

Dean
School of Medicine and Health Sciences
University of Development Studies
Tamale

Dear Sir,

RE: PERMISSION TO CONDUCT STUDY

In reference to your response to my letter on the same subject dated 25th October 2017, I write to present you an ethical clearance letter from the College of Health Sciences Ethical and Protocol Review Committee, University of Ghana. In addition to this, I would like to present the study instruments for your kind consideration.

I look forward to a favourable response to this request.

Thank you.

Yours faithfully,

Abdul Malik Sulley

(2) Abdul Malik Sulley
You are cleared to conduct your study. I have seen the Ethical clearance & the instrument of the study
10.11.17

Figure A3: Institutional approval from University of Development Studies

Centre for Tropical Clinical Pharmacology & Therapeutics

14th November 2017

Dean
School of Medicine
University of Cape Coast
Cape Coast

Dear Sir,

PERMISSION TO CONDUCT STUDY

My name is Abdul Malik Sulley, a PhD candidate at University of Western Ontario, Canada. I am also a principal research assistant at Centre for Tropical Clinical Pharmacology & Therapeutics, University of Ghana School of Medicine and Dentistry. I write to request permission to conduct a survey and focus group discussions on the topic **Investigating the use of m-health for learning and clinical practice by students in medical and dental schools in Ghana.**

The study population for the survey is clinical year medical and dental students in all medical and dental schools in Ghana. Students who participate in the survey (online or paper form) may opt to also participate in one of two focus group discussions to be held per school. In order to protect student anonymity, I would like to request that recruitment emails are sent directly by your administration so that I do not have access to student email addresses.

Furthermore, the study involves engaging with faculty members and relevant staff members in separate focus group discussions respectively, per school. Relevant staff members include deans, directors, heads of department, executive secretaries, registrars, assistant registrars, library personnel, technical support staff, and teaching and learning support staff. Attached is an abstract of the study proposal for your kind consideration. I am pleased to present the full proposal if need be.

Attached also is a letter of ethical clearance issued by the University of Ghana, College of Health Sciences Ethical and Protocol Review Committee for your perusal.

I look forward to a favourable response to this request.

Thank you.

Yours faithfully,

Abdul Malik Sulley

② To
Approved. Please contact Dr Sulley to update us when complete.
27/11/17.

③ Noted
27/11/17

Figure A4: Institutional approval from University of Cape Coast

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICAL SCIENCES / KOMFO ANOKYE TEACHING HOSPITAL

COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/578/17

18th December, 2017.

Dr. Isola Ajiferuke
Faculty of Information & Media Studies
The University of Western Ontario
CANADA.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"Investigating the Use of m-Health for Learning and Clinical Practice by Students in Medical and Dental Schools in Ghana."***

Proposed Sites: ***Accra College of Medicine; Kwame Nkrumah University of Science and Technology School of Medical Sciences and Dental School; University for Development Studies School of Medicine; University of Health and Allied Sciences School of Medicine; University of Ghana School of Medicine and Dentistry and University of Cape Coast School of Medical Sciences.***

Sponsor: ***Principal Investigator.***

Your submission to the Committee on Human Research, Publications and Ethics on the above named protocol refers.

The Committee reviewed the following documents:

- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire.
- Focus Group Guide.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, beginning 18th December, 2017 to 17th December, 2018 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Yours faithfully,

Osomfo Prof. Sir J. W. Acheampong MD, FWACP
Chairman

Room 7 Block J, School of Medical Sciences, KNUST, University Post Office, Kumasi, Ghana
Phone: +233 3220 63248 Mobile: +233 20 5453785 Email: chrpe.knust.kath@gmail.com / chrpe@knust.edu.gh

Figure A5: Ethics approval from Kwame Nkrumah University of Science and Technology

Appendix K: Sources of major questionnaire items

Source	Questionnaire item
Ellaway et al. (2014, p. 138)	1. How often do you use your mobile device? 2. Did you previously own? (list of devices) 3. Where do you use your mobile device? 4. In which of the following session types do you use your mobile device? (list) 5. What mobile applications do you use most frequently? (list) 6. How do you learn about new applications? 7. Do you use your mobile device as a replacement for your laptop? 8. Where do you seek support? 9. I use my mobile device for . . . (list of uses) 10. I feel confident using my mobile device for learning . . . 11. I feel competent using my mobile device for learning . . . 12. What are the biggest benefits and drawbacks to you individually of using mobile devices?
Venkatesh et al. (2012, p. 178)	***Performance Expectancy*** PE1. I find mobile Internet useful in my daily life. PE2. Using mobile Internet increases my chances of achieving things that are important to me. (dropped) PE3. Using mobile Internet helps me accomplish things more quickly. PE4. Using mobile Internet increases my productivity. ***Effort Expectancy*** EE1. Learning how to use mobile Internet is easy for me. EE2. My interaction with mobile Internet is clear and understandable. EE3. I find mobile Internet easy to use. EE4. It is easy for me to become skillful at using mobile Internet. ***Social Influence*** SI1. People who are important to me think that I should use mobile Internet. SI2. People who influence my behavior think that I should use mobile Internet. SI3. People whose opinions that I value prefer that I use mobile Internet. ***Facilitating Conditions*** FC1. I have the resources necessary to use mobile Internet. FC2. I have the knowledge necessary to use mobile Internet. FC3. Mobile Internet is compatible with other technologies I use. FC4. I can get help from others when I have difficulties using mobile Internet. ***Hedonic Motivation*** HM1. Using mobile Internet is fun. HM2. Using mobile Internet is enjoyable. HM3. Using mobile Internet is very entertaining.

	Price Value PV1. Mobile Internet is reasonably priced. PV2. Mobile Internet is a good value for the money. PV3. At the current price, mobile Internet provides a good value. ***Habit*** HT1. The use of mobile Internet has become a habit for me. HT2. I am addicted to using mobile Internet. HT3. I must use mobile Internet. HT4. Using mobile Internet has become natural to me. (dropped) ***Behavioral Intention*** BI1. I intend to continue using mobile Internet in the future. BI2. I will always try to use mobile Internet in my daily life. BI3. I plan to continue to use mobile Internet frequently. ***Use*** Please choose your usage frequency for each of the following: a) SMS b) MMS c) Ringtone and logo download d) Java games e) Browse websites f) Mobile e-mail
Scott et al. (2017, p. 182)	Use of a mobile device to 1. Improve learning 2. Improve clinical knowledge and skills 3. Improve basic science knowledge and skills 4. Improve timetabling or organisation 5. Communicate Best uses 1. Access drug information 2. Access treatment information 3. Access up-to-date information 4. Confirm information I knew 5. Access calendar or “to do” lists 6. Access communication facilities Worst uses 1. Technical difficulties 2. Internet access difficulties 3. Difficult to use 4. Screen too small 5. It distracts me 6. Unsure of tutors’/clinicians’ reaction 7. Unsure of patients’/carers’ reaction *Response options: strongly agree, agree, neutral, disagree or strongly disagree*

Davies et al. (2012, p. 5)	Factors preventing PDA use 1. Electronic device not preferred learning modality 2. Theft/loss
Wittich et al. (2016, p. 71)	Factor 1: app educational value 1. Using the course app improved my learning experience 2. Using the course app helped me to stay more engaged 3. Using the course app enabled me to gain more knowledge 4. Using the app will help me apply what I have learned to clinical practice 5. Using the course app enhanced my education 6. I would be more likely to attend a CME course if it has an app 7. I am likely to use the app after the conference is over Factor 2: app appeal and usability 1. The course app was easy to use 2. The course app was intuitive to use 3. I would recommend a similar app for other CME courses

Curriculum Vitae

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